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(54) MONO DIAMETER WELLBORE CASING

BOHRLOCHFUTTERROHR MIT EINHEITLICHEM DURCHMESSER TÜBAGE DE PUITS DE FORAGE À DIAMETRE UNIQUE

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ized by: positioning the expansion device and the exvice within an expandable tubular member, characterin a wellbore, comprising: positioning an expansion deinvention there is provided a method of forming a casing [0000] According to a second aspect of the present

eter to another effective expansion diameter. sion cone assembly from one effective expansion diammember, and means for adjusting the adjustable expanstive to the expandable tubular member and the support displacing the adjustable expansion cone assembly relexpansion cone assembly, characterised by: means for sn expandable tubular member coupled to the adjustable bsusion cone assembly coupled to the support member; per comprising: a support member, an adjustable exand plastically deforming an expandable tubular memtion there is provided an apparatus for radially expanding [0002] According to a first aspect of the present inven-

Summary of the Invention

for forming and/or repairing wellbore casings. oue or more of the limitations of the existing procedures. [0004] The present invention is directed to overcoming the pre-characterising features of claim 1.

[0003] WO 02/053867 discloses an apparatus having and the large volume of cuttings drilled and removed. tions in hole dismeters drilled in the course of the well, ening, required equipment changes due to large vanavolved due to required cement pumping, cement harddrill cuttings. Moreover, increased drilling rig time is inlarge drill bits and increased volumes of drilling fluid and ciessed costs que to peavy casing handling equipment, wellbore. Such a large borehole diameter involves inborehole diameter is required at the upper part of the quence of this nested arrangement a relatively large sest the casings from the borehole wall. As a conseouter surfaces of the casings and the borehole wall to ward direction. Cement annull are provided between the rangement with casing diameters decreasing in downthe upper interval. Thus, the casings are in a nested arlower interval is of smaller diameter than the casing of As a consequence of this procedure the casing of the previously installed casing of an upper borehole interval. stalled in a lower borehole interval is lowered through a drilled in intervals whereby a casing which is to be infrom the formation into the borehole. The borehole is outiow of driling fluid into the formation or inflow of fluid collapse of the borehole wall and to prevent undesired number of casings are installed in the borehole to prevent [0002] Conventionally, when a wellbore is created, a

Background of the Invention

wellbore casings to facilitate oil and gas exploration. exploration, and in particular to forming and repaining [1000] This invention relates generally to oil and gas

Describtion

able tubular member.

radial expansion and plastic deformation of the expanda ball or dart within the ball or dart seat to initiate the lustrations of the apparatus of Figs. 8a - 8e after placing [0015] Figs. 9a -9e are fragmentary cross-sectional ilment on the bottom of the wellbore.

illustrations of the apparatus of Figs. 7a -7e after place-[0014] Figs. 8a - 8e are fragmentary cross-sectional 10mation.

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casing within a wellbore that traverses a subterranean of an appaiatus for forming a mono dismeter wellbore instrations of the placement of an exemplary embodiment [0013] Figs. 7a - 7e are fragmentary cross-sectional ilthe expandable tubular member:

panded for radially expanding and plastically deforming tional illustration of the expansion cone assembly ex-[0012] Fig. 6 is a schematic fragmentary cross-sec-

sembly pushed by the actuator into an open wellbore. -bottom of the wellbore and with the expansion cone asno diameter casing, with the tubular member lifted off the actuator and expansion cone assembly for forming a mogripping mechanism engaging the tubular member, an tional illustration of an expandable tubular member, a [0011] Eig. 5 is a schematic tragmentary cross-secmember for running into a wellbore.

diameter casing and a float shoe supporting the tubular tuator, an expansion cone assembly for forming a mono gripping mechanism within the tubular member, an actional illustration of an expandable tubular member, a [0010] Fig. 4 is a schematic fragmentary cross-sec-2 according to another aspect to the invention.

tion of the mono diameter wellbore casing of Figs. 1 and expansion cone assembly forming a mono diameter portional illustration of an expandable tubular member and [0009] Fig. 3 is a schematic fragmentary cross-secone aspect to the invention.

mono diameter well bore casing of Fig. 1 according to expansion cone assembly forming a bell portion of the tional illustration of an expandable tubular member and [0008] Fig. 2 is a schematic fragmentary cross-sec-

to the invention: smeter well bore casing formed according to one aspect

exbanslon cone-assembly running through a mono ditional illustration of an expandable tubular member and [0007] Fig. 1 is a schematic fragmentary cross-sec-

Brief Description of the Diswings

inside diameter:

wherein the first inside diameter is larger than the second second inside diameter using the expansion device, an upper portion of the expandable tubular member to a device; and radially expanding and plastically deforming lar member to a first inside diameter using the expansion fically deforming a lower portion of the expandable tubumember within the wellbore; radially expanding and plasexpansion device out of an end of the expandable tubular pandable tubular member into the wellbore; lowering the

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ent application serial no. 60/159,039, attorney docket no.

which are incorporated herein by reference. no. 25791.114, filed on 9/20/2002, the disclosures of patent application serial no :60/412,488, attorney docket 25791, 112, filed on 9/20/2002, and (48) U.S. provisional ent application serial no. 60/412,487, attorney docket no. 25791:127, filed on 9/20/2002, (47) U.S. provisional patent application serial no. 60/412,187, attorney docket no. -159 1.128, filed on 9/20/2002, (46) U.S. provisional patent application senal no. 60/412,187, attomey docket no. -25791.121, filed on 9/20/2002, (45) U.S. provisional patent application senal no. 60/412,544, attorney docket no. -1591.118, filed on 9/20/2002, (44) U.S. provisional patent application senal no..60/412,653, attorney docket no.

L. There is an overlapping portion 26 where the bell porsecond inside diameter inside diameter IDS and a length diameter ID1 and bell portions 22a and 22b having a mono diameter portions 28a and 28b with a first inside cording to the feachings of the present invention include formed from expandable tubular members 14 and ac-The existing casing 18 sections 18a and 18b have been: being formed, according to one aspect to the invention. a mono diameter wellbore casing 18 in the process of 12 through a plurality of casing sections 18a and 18b of all supported by a float shoe 32 for running into a wellbore ported by a fubular support 30 (such as a drill pipe 30); member 14 and an expansion cone assembly 16 supparatus:10 in a-wellbore 12 with an expandable tubular [0030] Fig. 1 shows a schematic illustration of an ap-

18 of Figs. 1 and 2, overlaps with the wellbore casing ing section 18c of the mono diameter well bore casing of the mono diameter wellbore casing. The wellbore casing the tubular member 14 to the desired inside diameter large diameter of cone 20, is provided for radially expandter. Another cone 24, having a diameter smaller than the collapsed, or is other wise adjusted, to a smaller diameration the diameter of the large adjustable cone 20-is the portion 28 above the bell portion 22. In this configuable tubular member 14 to the desired mono diameter at cone assembly 16 positioned for expanding the expandpandable tubular member 14 of Fig. 2, with the expansion [0032] Fig. 3 shows a schematic illustration of the ex-(1991 021) m7:34 Juods of qu 10 (1991 001) m2.05 Juods of and therefore the bell portion S2 may have a length up it is contemplated applicants that the overlap-length 26 nested casing sections 18a, 18b, and 18c. For example, the desired length of overlapping lengths 26 between casing 18. The length of the bell portion 20 depends upon desired inside diameter of the mono diameter wellbore eter of the bell portion 20 is at least slightly larger than a clently large so that the resulting expanded inside diamsembly 16 that has an adjustable cone diameter suffiformed by the large cone 20 of the expansion cone asber 14 to form a bell portion 22. The bell portion 22 is diameter of the lower end of the expandable tubular mem-20 of the expansion cone assembly 16 to expand the pandable tubular member 14, acted upon by a large cone [0031] Fig. 2 shows a schematic illustration of the extions 22a overlap of the casing section 18b.

25791 117, filed on 9/20/2002, (43) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791:120, filed on 8/23/2002, (42) U.S. provisional patent application serial no. 60/405,394, attorney docket no. -tsq isnoisivorq. 2:U (11), 2002\S2800 ho belit ;er1:19723 ent application serial no, 60/405,610, attomey docket no. -15q filed on 7/24/2002, (40) U.S. provisional patent application serial no. 60/398,061, attorney docket no. Jisq Isnoizivorg .2.U (65) ,S00S\eft\Y no belf ;801:16\ZS application senal-no. 60/397;284; attorney docket no. 25791:90, filed on 6/26/2002, (38) U.S. provisional patent ent application serial no. 60/391,703, attorney docket no. -167 1 108, filed on 6/12/2002; (37) U.S. provisional patent application serial no. 60/387,961; attorney docket no. -184 lanoizivorg. S.U (36) 1.5000\0.50 holes on 6/10/2002, (36) P.U. 1972 application senal no 60/387,486, attorney docket no. 104, filed on 5/6/2002, (35). 9. 9. provisional patent application serial no: 60/380,147; attorney docket no. Ineted lanoisivorg. S.U (45), 2002/S1 h no belil, 26, 19732 application senal no: 60/372,048; attorney docket no. the state on 1/7/2002, (33) U.S. provisional patent ent application serial no. 60/346,309, attorney docket no -184 Isnoizivorq . S. U (SE) , 1005\75\27 no balit ;89.19725 ent application senal no. 60/343,674, attorney docket no. 25791.70, filed on 12/10/2001, (31) U.S. provisional patplication serial no. 10/016,467, attorney docket no. -qs tnafsq villitu .2.U (0c) ,100S/2/01 no balfi ,63.1973S application serial no: 09/969,922, attorney docket no. trateg (tilitu .2.U (eS) ,100S/01/e no balit ,50.78.16∑62. application serial no. 60/3318,386, attorney docket no. 25791.67; filed on 9/6/2001, (28) U.S. provisional patent application senal no. 60/317,985, attorney docket no. Instaglismoizivorg : 2, U (SS) ; 100S\0S\8 no belft ; ed. 1678S application serial no 60/313,453, attorney docket no step is filed on 7/6/2001, (6S) U.S. provisional patent application senat no: 60/303,740, attomey docket no. 25.791.52, filed on 1/3/2001, (25) U.S. provisional patent application senal no: 60/259,486, attorney docket no: the familiar of the state of th application senal no: 60/262,434, attorney docket no: shering remoisivorg. RSJ, 1500/202/S no belit. 02.1973S application senal no: 60/270,007, attorney docket no: 25791.48, filed on 10/2/2000, (S2) U.S. provisional patent application serial no. 60/237,334, attorney docket no. 25791.47, filed on 9/18/2000, (21) U.S. provisional patent application serial no: 60/233,638, attorney docket no. maisq isnoizivorq .2.U (02) ,0005/85\7 no balfi, 34.1973S application senal no. 60/221,645, attorney docket-no. 195791.45; filed on 7/28/2000, (91) Provisional patent ent application serial no:: 60/221,443, attomey docket no. -15q lanoisivorg .2.U (81), (98e1/21/11 no belit, e2.19725 application senal no. 60/165;228, attomey docket no. statistics on 6/19/2000, (71) U.S. provisional patent ent application serial no. 60/212.359, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application senal no. 60/159,033, attorney docket no.

[0016] Figs. 10a 10e are fragmentary cross-sectional illustrations of the apparatus of Figs. 9a-9e after the initiation of the radial expansion and plastic deformation of the aluminum sleeve within the shoe.

[0017] Fig. 11a -11b is a fragmentary cross-sectional illustration of an exemplary embodiment of an apparatus for radially expanding and plastically deforming a tubular member that includes an adjustably expandable expansion cone assembly.

[0018] Fig. 12 is a fragmentary cross-sectional illustration of an upper cone portion of the apparatus for radially expanding and plastically deforming a tubular member of Figs. 11a - 11b.

[0019] Fig. 13 is a fragmentary cross-sectional illustration of a lower cone portion of the apparatus for radially expanding and plastically deforming a tubular member of Figs. 11a-11b.

[0020] Fig. 14 is a fragmentary cross-sectional illustration of an overlapping portion of the apparatus for radially expanding and plastically deforming a tubular member of Figs. 11a - 11b, 12 and 13.

[0021] Fig. 15 is a fragmentary cross-sectional and perspective illustrations of the upper cam assembly of the apparatus for radially expanding and plastically deforming a tubular member of Figs. 11a - 11b.

[0022] Fig. 16 is a fragmentary cross-sectional and perspective illustrations of the lower cam assembly of the apparatus for radially expanding and plastically deforming a tubular member of Figs. 11a-11b.

[0023] Fig. 17a -17b is a fragmentary cross-sectional illustration of an exemplary embodiment of an apparatus for radially expanding and plastically deforming a tubular member that includes an adjustably expandable expansion cone assembly of Figs. 11a - 11b activated for cementing.

[0024] Fig. 18a -18b is a fragmentary cross-sectional illustration of an exemplary embodiment of an apparatus for radially expanding and plastically deforming a tubular member that includes an adjustably expandable expansion cone assembly of Figs. 11a - 11b activated for adjusting the expansion diameter:

[0025] Fig. 19 is a fragmentary cross-sectional illustration of an overlapping portion of the apparatus for radially expanding and plastically deforming a tubular member adjusted to an intermediate expansion diameter.

[0026] Fig. 20a -20b are fragmentary cross sectional illustrations of the apparatus of Figs. 10d-10e after the completion of the radial expansion and plastic deformation of the aluminum sleeve within the shoe:

[0027] Figs. 21a-21b are fragmentary cross-sectional illustrations of the apparatus of Figs. 20a-20b after displacing the sliding sleeve valve within the shoe to permit circulation around the ball or dart.

[0028] Figs. 22a-22b are fragmentary cross sectional illustrations of the apparatus of Figs. 21a-21b during the injection of cement into the annulus between the radially expanding tubular member and the wellbore using the bypass circulation provided by the displaced sliding

sleeve valve within the shoe.

Detailed Description of the Illustrative Embodiments

4

[0029] Figs. 1- 6 illustrate several illustrative embodiments of a device and method for forming a mono diameter well bore casing using an expansion assembly including two cone diameters, one of which is larger than the other for forming a bell (sometimes called a skirt) section for overlapping expandable tubular members so that the effort required for the expansion assembly to expanded two overlapping tubular members is reduced. The other cone diameter is sized for expanding the tubular members to the desired diameter along the length of the tubular member thereby resulting in a mono-diameter well bore casing. The two diameters may be provided with a conventional adjustable size expansion cone having two expansion diameters, one larger than the other. The larger diameter is adjusted to a smaller diameter after a bell section of an expandable tubular member is formed and then the remainder of the expandable tubular member is expanded to a the desired internal diameter for the mono diameter well bore casing. Conventional adjustably expandable cones can be used according to the invention. In several alternative embodiments, the invention is implemented as described in Figs. 7a -7e; 8a -8e, 9a- 9e, 10a -10e, 11a -11b and 17a-17b, 18a-18b and 19a-19b with an exemplary adjustably expandable cone assembly as described in greater detail herein with reference to Figs. 11a - 11b, 12, 13, 14, 15 and 16. In other alternative embodiments the adjustably expandable cones of the invention may be implemented or using the methods and/or apparatus disclosed one or more of the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent no. 6,328,113, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895; attorney docket no. 25791.12.02, filed on 2/24/2000, (7) U.S. patent application serial no. 09/511,941; attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946; attorney docket no. 25791.17.02, filed on 6/7/2000; (9) U.S. patent application senal no. 09/559,122; attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S. provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999; (14) U.S. provisional patsection 18b along the overlapping length 26 and at the bell portion 22b. The inside diameter or the bell portion 22 and the outside diameter of the mono diameter portion 28 are the same to provide a tight fitting junction between the nested sections 18a, b, c and etc. For example, where the expandable tubular member 14 has a wall thickness of about 0.35 inches and for the desired inside diameter of the mono diameter wellbore casing is about 10.3 inches, after expansion, the inside diameter of the bell portion might be about 11.0 inches, or slightly less to provide a tight fit between the overlapping portions of the casing sections 18a, b, c and etc.

[0033] The large diameter cone 20 can be positioned above, below or effectively at the same position as the small diameter cone 24, without departing from certain aspects of the invention. Also, it will be understood by those of ordinary skill in the art; and based upon this disclosure, that the large diameter corresponding to the inside diameter of the bell portion can be provided by a first collapsible or adjustable cone 22; that provides the desired bell portion diameter and that can be collapsed to a smaller diameter, together-with a second-cone 24that provides the diameter for forming the mono diameter well bore casing. It will also be understood that in analternative embodiment the expansion to the mono-di- 25 ameter can be provided by adjusting the diameter of cone 22 to effectively become the smaller diameter cone 24 having a diameter corresponding to the desired monodiameter. It will further be understood that in another alternative embodiment the cone 24 is a distinct cone 24 30 either fixed at the desired mono diameter size or expandable to the desired mono diameter size.

[0034] Fig. 4 shows a schematic mono diameter casing forming apparatus 10, further depicting one arrangement of a mechanism for activating the expansion cone assembly 16 to expand the tubular member 14. The apparatus 10 is shown in a configuration for running into a wellbore 12. A drill pipe 30 supports the apparatus 10, as it is running down into the wellbore 12, with a connected float shoe 32. The drill pipe 30 may be a conventional drill pipe or other conventional down hole tubular support member. The float shoe may be a conventional float shoe or other tool guiding structure that serves the describe purpose attached to the drill pipe or other tubular support member. The float shoe 32 thus supports the new expandable tubular-member 14 that is to be added to and expanded for engagement with the lower end of the mono diameter wellbore casing 18 that has been previously formed. An gripping tool 34, sometimes called an anchorthat may be a device as shown or a conventional gripping tool or anchor, is provided to hold the expandable tubular member 14 fixed relative to one end of a hydraulic actuator 36, sometimes called a force multiplier mechanism that may be a device as shown or a conventional actuator or force multiplier. The hydraulic actuator 36 is configured and actuatable for moving the expansion cone assembly 16 relative to the expandable member 14, either in tension using sub 36a or in compression using sub 36b.

[0035] Fig. 5 schematically shows an embodiment of the mono diameter casing forming apparatus 10, with the gripping mechanism 34 engaging the tubular member 14, with the tubular member 14 lifted off the bottom of the well bore 12 and with the expansion cone 16 pushed by actuator 36 into the open wellbore 12. A conventional dart 53 or ball is dropped to seal the float shoe 32, or another conventional shut-off device such as a mechanical valve or a velocity valve is used and activated, so that fluid 38 forced through the drill pipe 22 increases pressure to activate the gripping tool 26. When the drill pipe 22 is set down at the bottom of the hole, the tension sub 36a of the actuator mechanism 36 is actuated. Pressure is increased in the drill pipe 30 and the gripping mechanism 34 is engaged to anchor the tubular member 14: Compression sub 36b is activated to lift the tubular liner 14 off the bottom of the wellbore and to push the cone assembly 16 into the open hole of wellbore 12.

[0036] Fig. 6 shows the expansion cone assembly 16 expanded for radially expanding and plastically deforming the expandable tubular member 14. The expansion of the expansion cone assembly is activated in a conventional manner, as with a dart 42 that is passed with the fluid 38 down through the drill pipe 30 to thereby cause appropriate port alignment and/or appropriate valve activation for the expansion cone assembly 16. An optional sacrificial protective sleeve 40 that protects the expansion cone assembly 16 while it is running into the wellbore breaks off when the expansion cone assembly is expanded. The protective sleeve 40 may be formed of a plastic or composite material so that the sacrificial protective sleeve easily breaks off and does not interfere with the expansion of the tubular member 14.

[0037] In an exemplary embodiment, as illustrated in Figs. 7a -7e, an apparatus 10 for forming a mono diameter wellbore casing 18 is positioned within a wellbore 12. The apparatus 10 includes, among other things, an expandable tubular member 14 and an adjustable expansion cone assembly 16. During placement of the apparatus 10 within the wellbore 12, the expandable tubular member 14 may be supported by the grip tool 34 and/or. the expansion cone assembly 16 and/or the float shoe 32. [0038] In an exemplary embodiment, as illustrated in Figs. 8a - 8e, the apparatus 10 is then positioned into contact with the bottom 44 of the wellbore 12. As a result. a shear pin 46 is sheared and a dog locking sleeve 48 is. driven upwardly thereby displacing a plurality of dogs 50. outwardly in the radial direction in a conventional manner. [0039] In an exemplary embodiment, as illustrated in Figs. 9a - 9e, a ball 52 or conventional dart may then be placed within the ball or dart seat 54 of the apparatus by injecting fluidic material 38 into the apparatus 10. As a result, the flow of fluidic material 38 through the float shoe 32 is blocked. The expansion cone assembly is also actuated in a conventional manner, for example with the pressure caused by the ball 52 or a dart 42 (as shown in Fig. 6 above), to-expand to the large diameter for expanding the bell. Pressure builds and the actuator 36 is

safety collar 66.

[0044] An end of an upper mandrel 74 is received with in and is coupled to the upper mandrel collar 70 that defines a passage 74s, a pluisibly of meshing from the mething in and from the mething in and from the indication of the forms of each plate in an external flange

mandrel 74. sleeve proximate the external flange 74c of the upper ceives, and is coupled to an end of the lower spacer upper mandrel. A retaining sleeve 84 mates with, relower packer cup 80 and the external flange-74c of the pled to the upper mandrel 74 proximate an end of the lower spacer sleeve 82 mates with, receives, and is couer cup 80 is a conventional Guiberson" packet cup. A sleeve.78. In an exemplary embodiment, the lower packupper mandrel 74 proximate an end of the upper spacer packer cup 80 mates with, receives and is coupled to the At proximate an end of the upper packer cup 76. A lower mates with, receives, and is coupled to the upper mandrel Cripetsoum backet cup. An upper spacer sleeve 78 podiment, the upper packer cup 76 is a conventional end of the upper mandrel collar 70. In an exemplary emand is coupled to the upper mandrel 74 proximate the [0045] An upper packer cup 76 mates with, receives 74c at another end.

10046) An end of a lower mandrel 86 defines a recess 86s that mates with receives, and is coupled to the external flange 74c of the upper mandrel. 74, a receese 86b that mates with, receives, and is coupled to the end of the upper mandrel a passage 86c, and an external flange 86d including circumferentially spaced apart meshing pins 88a and 88b further couple the recess 86a of the external flange. Torque of the lower mandrel 86 to the external flange 74c of the upper mandrel 86 to the external flange 74c of the lower mandrel 86 and the recess 86a of the end of the end of the external flange 74c of the lower mandrel 86 and the external flange 74c of the upper mandrel 86 and the external flange 74c of the upper mandrel 86 and the external flange 74c of the upper mandrel 74.

inner portion 90cb that has an arcuate cylindrical inner iaces, a tapered intermediate portion extending from the has arcuate cylindrical inner 90caa and outer 90cab surportion 90cs extending from the tubular base 90a that. assembly 90. Each of the cam arms 90c include an inner torque loads to the meshing teeth 90b of the upper cam external flange-86d of the lower mandrel 86 transmit eration, the meshing teeth 86da of the end face of the mate with and receive the lower mandrel 86. During opthe tubular base in the opposite longitudinal direction and spart cam arms 90c that extend from the other end of mandrel-86, and a plurality of circumferentially spaced of the end face of the external flange 86d of the lower and radial directions for engaging the meshing teeth 86da. extend from one end of the tubular base in the longitudinal circumterentially spaced apart meshing teeth 90b that 86 that includes an external flange 90aa, a plurality of base 90a for receiving and mating with the lower mandrel [0047] An upper cam assembly 90 includes a tubular

activated in tension to draw the large cone 20 upward partially through the expandable tubular member 14. Pressure can be released and reactivated in the actuator cone 20 of the expansion cone assembly 16 along the large and gripping tool 34 to repeatedly stroke the large cone 20 of the expansion cone assembly 16 along the large partial to the expansion to to the e

member 14. As a result, the expandable tubular memberto pull the expansion cone 24 into the expandable tubular the apparatus thereby causing the hydraulic actuator 36 38 furthermore increases the operating pressure within casing 18. The continued injection of the fluidic material desired diametrical size for forming the mono diameter fetial 38 also causes the adjustable cone 24 to reach the expandable tubular member 14. The injected fluidic maed to lock the top end of the hydraulic actuator 36 to the conventional dart seat 58. The gripping tool 34 is activatwith the fluidic material 38 into the apparatus 10 to a phate port (not shown) or an additional dart 56 injected creased fluidic pressure and a rupture disc in an approcasing 18, using conventional actuation, for example, inresponding-to the desired diameter of the mono diameter to collapse or adjust to a smaller diameter cone 24 cor-Figs. 10a--10e, the large diameter cone 20 is actuated. [0040] In an exemplary embodiment, as illustrated in the bell portion 22 of the casing.

14 is radially expanded:

[1004.1] The continued upward movement of the expansion cone pulls the float shoe 32 to the bottom end of the radially expanded tubular member 14. As a result, the end of the radially expanded tubular member 14 will import the dogs 50 thereby preventing the float shoe 32 from moving further in the upward direction. The continued upward movement of the expansion cone then will import the dogs 50 thereby preventing the float shoe 32 from moving further in the upward direction. The continued upward movement of the float shoe with the radially expanding a sleeve of the float shoe with

In one exemplary embodiment, as illustrated in the float shoe.

Figs. 11 a -11 b, 12, 13, 14, 15 and 16, the expansion cone assembly 16 is adjustable for providing two outside diameter: one outside diameter larger than the outside cone assembly may also be constructed in accordance outside diameter. The constructed in accordance cone assembly may also be constructed in accordance with the principles and design disclosed in U.S. provisional patent application sensi no. 60/387,961, altomey docket no. 25/91,108, filled on 6/12/2002, the disclosure of which is incorporated herein by reference. An exemplary embodiment includes a tubular support member 64 coupled to an end of a safety collar be that defines a coupled to an end of a safety collar be that defines a passage 66s and a recess 66b, at one end for receiving passage 66s and a recess 66b, at one end for receiving passage 66s and a recess 66b, at one end tor receiving passage 66s and a recess 66b, at one end tor receiving passage 66s and a recess 66b, at one end tor receiving passage 66s and a recess 66b, at one end tor receiving passage 66s and a recess 66b, at one end tor receiving

66c and 66d at another end.

[0043] A forque plate 68 is received within and is coupled to the recess 66c of the safety collar 66 that defines a passage 68a and a plurality of meshing received one end. An end of an upper mandrel collar 70 is received with and is coupled to the recess 66d of the safety collar 66 proximate an end of the torque plate 68 that defines 66 proximate an end of the torque plate 68 that defines a passage 68a. Torque pins 72a and 72b further couple a passage 68a. Torque pins 72a and 72b further couple

surface 90cba and an arcuate conical outer surface 90bbb, and an outer portion 90cc extending from the intermediate portion 90cc that has arcuate cylindrical inner 90cca and outer surfaces 90ccb.

[0048] A lower cam assembly 92 includes a tubular base 92a for receiving and mating with the lower mandrel 86 that includes an external flange 92aa, a plurality of circumferentially spaced apart meshing teeth 92b that extend from one end of the tubular base in the longitudinal and radial directions, and a plurality of circumferentially spaced apart cam arms 92c that extend from the other end of the tubular base in the opposite longitudinal direction and mate with and receive the lower mandrel 86. Each of the cam arms 92c include an inner portion 92ca extending from the tubular base 92a that has arcuate cylindrical inner 92caa and outer 92cab surfaces, a tapered intermediate portion 92cb extending from the inner portion 92ca that has an arcuate cylindrical inner surface 92cba and an arcuate conical outer surface 92cbb, and an outer portion 92cc extending from the intermediate 20° portion 92cb that has arcuate cylindrical inner 92cca and outer 92ccb surfaces.

[0049] In an exemplary embodiment, the upper and lower cam assemblies, 90 and 92, are substantially identical. In an exemplary embodiment, the cam arms 90c of the upper cam assembly 90 interleave the cam arms 92c of the lower cam assembly 92. Furthermore, in an exemplary embodiment, the cam arms 90c of the upper cam assembly also overlap with the cam arms 92c of the lower cam assembly 92 in the longitudinal direction thereby permitting torque loads to be transmitted between the upper and lower cam assemblies.

[0050] A plurality of upper expansion cone segments 96 are interleaved among the cam arms 90c of the upper cam assembly 90. Each of the upper expansion cone segments 96 include inner portions 96a having arcuate cylindrical inner surfaces 96aa, and an arcuate cylindrical outer surface 96ab, intermediate portions 96b extending from the interior portions that have an arcuate conical inner surface 96ba and arcuate cylindrical and spherical outer surfaces, 96bb, and outer portions 96c having arcuate cylindrical inner and outer surfaces, 96ca and 96cb. In an exemplary embodiment, the outer surfaces 96ab of the inner portions 96a of the upper expansion cone segments 96 define hinge grooves 96d that receive and are pivotally mounted upon the internal -flange 94d of the upper retaining sleeve 94.

[0051] The arcuate inner cylindrical surfaces of the inner portion 96a mate with and receive the lower mandrel 86, the arcuate inner cylindrical surfaces of the inner portion 96a also mate with and receive the arcuate cylindrical outer surfaces of the outer portions 92cc of the corresponding cam arms 92c of the lower cam assembly 92, and the arcuate inner conical surfaces 96ba of the inner portion 96a mate with and receive the arcuate conical outer surfaces of the intermediate portions 92cb of the corresponding cam arms 92c of the lower cam assembly 92.

[0052] A plurality of lower expansion cone segments 98 are interleaved among, and overlap, the upper expansion cone segments 96 and the cam arms 90c of the lower cam assembly 90. In this manner, torque loads may be transmitted between the upper and lower expansion cone segments, 96 and 98. Each of the lower expansion cone segments 98 include inner portions 98a having arcuate cylindrical inner surfaces, 98aa, and an arcuate cylindrical outer surface 98ab, intermediate portions 98b extending from the interior portions that have an arcuate conical inner surface 98ba and arcuate cylindrical and spherical outer surfaces, 98bb, and outer portions 98c having arcuate cylindrical inner and outer surfaces, 98ca and 98cb. In an exemplary embodiment, the outer surfaces 98ab of the inner portions 98a of the upper expansion cone segments 98 define hinge grooves 98aba that receive and are pivotally mounted upon the internal flange 100d of a lower retaining sleeve 100.

[0053] The arcuate inner cylindrical surfaces 98aa mate with and receive the lower mandrel 86, the arcuate inner cylindrical surfaces 98aa also mate with and receive the arcuate cylindrical outer surfaces of the outer portions 90cc of the corresponding cam arms 90c of the upper cam assembly 90, and the arcuate inner conical surfaces 98ba mate with and receive the arcuate conical outer surfaces of the intermediate portions 90cb of the corresponding cam arms 90c of the lower cam assembly 90.

[0054] In an exemplary embodiment, the geometries of the upper and lower expansion cone segments 96 and 98 are substantially identical. In an exemplary embodiment, the upper expansion cone segments 96 are tapered in the longitudinal direction from the ends of the intermediate portions 96b to the ends of the outer portions 96c, and the lower expansion cone segments 98 are tapered in the longitudinal direction from the ends of the intermediate portions 98b to the ends of the outer portions 98c. In an exemplary embodiment, when the upper and lower expansion segments, 96 and 98, are positioned in a fully expanded position, the arcuate cylindrical outer surfaces 96ab of the upper and lower expansion cone segments 96 define a contiguous cylindrical surface, the arcuate spherical outer surfaces of the upper and lower expansion cone segments, 96bb and 98bb, define a contiquous arcuate spherical surface, and the arcuate cylindrical outer-surfaces of the upper and lower expansion cone segments define a contiguous cylindrical surface. [0055] An end of a lower retaining sleeve 100 defines a passage 100a for receiving and mating with the outer circumferential surfaces of the external flange 92aa and the meshing teeth 92b of the lower cam assembly 92, and an inner annular recess 100b, and includes an internal flange 100c for retaining the external flange of the lower cam assembly, and an internal flange 100d at one: end of the lower retaining sleeve that includes a rounded interior end face for mating with corresponding hinge grooves of the lower expansion cone segments 98 thereby pivotally coupling the lower expansion cone segments-

to the lower retaining sleeve.

[0056] In an exemplary embodiment, the arcuste cy-

arcuate cylindrical outer surfaces of the lower expansion faces of the upper expansion cone segments 96 and the exemplary embodiment, the arcuate cylindrical outer surthe outer surface of the upper retaining sleeve 94. In an the lower expansion cone segments 98 are aligned with ments 96 and the arcuste cylindrical outer surfaces of findrical outer surfaces of the upper expansion cone seg-

lower retaining sleeve 100. cone segments are allgned with the outer surface of the

defines a passage 102b at one end for receiving an end coupled to an end of the lower retaining sleeve 100 that lower cam assembly 92 is received within and threadably teeth 1023 for engaging the meshing teeth 92b of the a plurality of circumferentially spaced apart meshing. [700] An end of a float shoe adaptor 102 that includes

102b of the float shoe adaptor 102 that defines a passage as and is received within and mates with the passage tace of the tubular base 92a of the lower cam assembly bne end of a retaining sleeve 104 abuts the end from the meshing teeth 102a of the float shoe adaptor. the lower cam assembly 92 transmit toque loads to and bers 1021a. During operation, the meshing teeth 92b of end that includes a plurality of torsional coupling memflange 102e, and a torsional coupling 102f at the other passages 102d at the other end, and includes an internal duced inside diameter at another end, a plurality of radialof the lower mandrel 86, a passage 102c having a re-

[0029] A stop nut 106 receives and is threadably coufloat shoe adaptor 102. ceived within and mates with the passage 102c of the taining sleeve, having a reduced outside diameter, is reand includes a flange 104d, and another end of the rethroat passage 104b including a ball valve seat 104c, 104s for receiving an end of the lower mandrel 86, a

upper packet cup 76, the lower packet cup 80, the lower 64, the safety collar 66, the upper mandrel collar 70, the member 14 that surrounds the tubular support member and the float shoe 1.16. An end of an expandable tubular may be transmitted between the float shoe adaptor 102 a valveable passage 116b. In this manner torsional loads the salt t egesseq's seniteb 1srt 10t totabs each isoft releasably coupled to the torsional coupling 102f of the end of a float shoe 116 mates with and is 1201 rotgebs sone tsoft ent to b201 segessed leibst ent discs 114 are releasably coupled to and positioned within upper cam assembly 92 and the locking dogs 110. Burst ant to 626 each reludut ent to sone gnicopposing positioned within an end of the refaining sleeve-104 bejustiment shim 1.12 receives the lower mandrel 86 and is coupled to the lower mandrel 86, and a disc shaped adthe retaining sleeve 104 that receive and are releasably 104. Locking dogs 110 are positioned within an end of releasably couple the stop nut, 106 to the retaining sleeve 104a of the retaining sleeve 104, and shear pins 1,08 pled to the end of the lower mandrel 86 within the passage

mandrel 86, the upper expansion cone-segments 96, the

spherical external surfaces; 96bb and 98bb, of the upper expansion process, the interface between the arcuste [0064] In an exemplary embodiment, during the radial es ciested by the packer cups.

through the expandable tubular member by the axial forcpansion cone segments, 96 and 98, are pulled upwardly expandable tubular member 14, the upper and lower exvide a fluid tight seal against the interior surface of the lower backer cup 80 and/or the upper packer cup 76 proexpandable fubular member. Furthermore, because the pack-up, fluidic seal against the interior surface of the 14, and the upper packer cup 76 provides a secondary, the interior surface of the expandable tubular member backet cup 80 provides the primary fluidic seal against by the upper packer cup 76. In this manner, the lower cnb 80 is captured and sealed against further leakage the pressured fluidic material 38 past the lower packer [00e3] In an exemplary embodiment, any leakage of

plastic detormation of the expandable tubular member thereby control the initiation of the radial expansion and injected fluidic material 38 within the passage 102c and the burst discs 114 sense the operating pressure of the 14 is plastically deformed and radially expanded. Thus, member 14. As a result, the expandable tubular member relative to the float shoe 116 and the expandable tubular lower expansion cone segments, 96 and 98, upwardly lower packer cup 80 thereby displacing the upper and terior of the expandable tubular member 14 below the tion of the fluidic material 38 thereby pressurizes the in-102d of the float shoe adaptor 102. The continued injecthe burst discs 114 positioned within the radial passages erating pressure within the passage 1,02c bursts open 66a,-74a,-86c, and 102c. As a result, the increased opterial 38 into the apparatus 10 through the passages 64a, sage 116b of the float shoe 116 by injecting a fluidic mathen be positioned within and blocking the valveable passi 22 lled a dV1 bna aV1 api ni batatizulli aA [Sa00]

per 14 and the borehole 12: within the annulus between the expandable tubular memthis manner, an annular sealing layer may be formed material 104 is a hardenable fluidic sealing material in the borehole 12: In an exemplary embodiment, the fluidic annulus between the expandable tubular member 14 and sages 64a, 66a, 74a, 86c, 102c, 116a, and 116b into the is then injected into the apparatus 10 through the pasexample, from vertical to horizontal, A fluidic material 38 18. The borehole 12 may be oriented in any position, for formation that may include a preexisting wellbore casing for example, a borehole 12 that traverses a subterranean partially positioned within a preexisting structure such as, [16061] During operation, the apparatus 10 is at least

-86 bns 86 98bb, of the upper and lower expansion cone segments, by the arcuste spherical external surfaces, 96bb and float shoe 116 and is movably coupled to and supported adaptor 102, is coupled to and receives an end of the lower expansion cone segments 98, and the float shoe

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and lower expansion cone segments, 96 and 98, and the interior surface of the expandable tubular member 14 is not fluid tight. As a result, the fluidic material 38 may provide lubrication to the entire extent of the interface between the cylindrical external surfaces, 96bba and 98cb, and the arcuate spherical external surfaces, 96bb and 98bb, of the upper and lower expansion cone segments, 96 and 98, and the interior surface of the expandable tubular member 14. Moreover, experimental test results have indicated the unexpected result that the required operating pressure of the fluidic material 38 for radial expansion of the expandable tubular member 14 is less when the interface between the cylindrical external surfaces, 96bba and 98cb,- and the arcuate spherical external surfaces, 96bb and 98bb, of the upper and lower expansion cone segments, 96 and 98, and the interior surface of the expandable tubular member 14 is not fluid tight. Furthermore, experimental test results have also demonstrated that the arcuate spherical external surface provided by the arcuate spherical external surfaces, 96bb and 98bb, of the upper and lower expansion cone segments, 96 and 98, provides radial expansion and plastic deformation of the expandable tubular member 14 using lower operating pressures versus an expansion cone having a conical outer surface.

[0065] In an exemplary embodiment, as illustrated in Figs. 18a, 18b and 19, the upper and lower expansion cone segments, 96 and 98, may then be adjusted to a desired expansion diameter by placing a ball 57 within the ball valve seat 104c of the throat passage 104b of the retaining sleeve 104. The continued injection of the fluidic material 38, after the placement of the ball 57 within the ball valve seat 104c, creates a differential pressure across the ball 57 thereby applying a downward longitudinal force onto the retaining sleeve 104 thereby shearing the shear pins 108. As a result, the retaining sleeve 104 is displaced in the downward longitudinal direction relative to the float shoe adaptor 102 thereby permitting the locking dogs 110 to be displaced outwardly in the radial direction. The outward radial displacement of the locking dogs 110 disengages the locking dogs from engagement with the lower mandrel 86. Thus, the shear pins 108 sense the operating pressure of the injected fluidic material 38 within the throat passage 104b and thereby controlling the initiation of the collapsing of the upper and lower expansion cone segments, 96 and 98 to a smaller diameter.

[0066] The continued injection of the fluidic material 38 continues to displace the retaining sleeve 104 in the downward longitudinal direction relative to the float shoe adaptor 102 until the external flange 104d of the retaining sleeve 104 impacts, and applies a downward longitudinal force to, the internal flange 102e of the float shoe adaptor. As a result, the float shoe adaptor 102 is then also displaced in the downward longitudinal direction relative to the lower mandrel 86. The downward longitudinal displacement of the float shoe adaptor 102 relative to the lower mandrel 86 causes the lower cam assembly 92;

the lower expansion cone segments 98, and the lower retaining sleeve 100, which are rigidly attached to the float shoe adaptor, to also be displaced downwardly in the longitudinal direction relative to the lower-mandrel 86, the upper cam assembly 90, and the upper expansion cone segments 96. The downward longitudinal displacement of the lower cam assembly 92 relative to the upper expansion cone segments 96 causes the upper expansion cone segments to slide down the conical external surfaces 92cbb of the lower cam assembly and thereby pivot inwardly in the radial direction about the internal flange 94d of the upper retaining sleeve 94. The downward longitudinal displacement of the lower expansion cone segments 98 relative to the upper cam assembly 90 causes the lower expansion cone segments 98 to slide down the external conical surfaces 90cbb of the upper cam assembly and thereby pivot inwardly in the radial direction about the internal flange 100d of the lower retaining sleeve. As a result of the inward radial movement of the upper and lower expansion cone segments, 96 and 98, the arcuate external spherical surfaces, 96bb and 98bb, of the upper and lower expansion cone segments, 96 and 98, provide outer arcuate expansion surfaces having a smaller diameter.

[0067] The downward longitudinal movement of the retaining sleeve 94 and float shoe adaptor 102 relative to the lower mandrel 86 is stopped when the stop nut 106 impacts the locking dogs 110. At this point, the apparatus 10 may then be removed from the interior of the expandable tubular member 14.

[0068] Thus, the apparatus 10 may be removed from the expandable tubular member 14 prior to the complete radial expansion and plastic deformation of the expandable tubular member by controllably collapsing the upper and lower expansion cone segments, 96 and 98. As a result, the apparatus 10 provides the following benefits: (1) the apparatus is removable when expansion- problems are encountered; (2) lower expansion forces are required because the portion of the expandable tubular. member 14 between the packer cups, 76 and 80, and the expansion cone segments is exposed to the expansion fluid pressure; (3) the expansion cone segments can be run down through the expandable tubular member, prior to radial expansion, and then the expansion cone segments can be expanded; (4) the expansion cone segments can be expanded to one diameter for forming abell portion; and (5) the expansion cone segments can be adjusted to a second diameter for expanding the remainder of the expandable tubular member.

[0069] In another exemplary embodiment, as illustrated in Figs. 20a - 20b, upward movement of the apparatus 10 causes the expansion cone for the sleeve 60 to completely radially expand the sleeve 62 of the float shoe 32 and a cementing probe 118 is pulled downward until stopped from further movement by the cementing probe locking ring 119. As a result of the complete radial expansion of the sleeve, the floats shoe is now firmly coupled to the end of the radially expanded-tubular member.

process, an expension cone assembly having family involved in several alternative embodiments, the expandative embodiments, the expandation dismeters may be replaced with two separate adjustable cones one adjustable to a diameter corresponding to the desired bell portion diameter corresponding to the desired bell portion diameter corresponding to the desired diameter of the mono diameter casing ing to the desired diameter of the mono diameter casing. [0076] In several alternative embodiments, the expandable adjustable expansion diameter may be replaced with an adjustable expansion diameter on a diameter corresponding to the desired bell portion diameter or corresponding to the desired bell portion diameter.

[0074] In several alternative embodiments, Guiberson* cup seals may be added above the expansion cone
that provide a fluid tight seal between the drill pipe and
the interior surface of the expandable tubular member.
In this manner, in the alternative embodiment, the fluid
in this manner, in the alternative embodiment, the fluid
the same below the cup seals pulls the expansion cone
upwardly through the expandable tubular member.

using the hydraulic actuator 36.

[0073] After the cement has cured, the float collar 32 may be drilled out and another expanded and plastically defermed within the wellbore with the upper end of the other formed within the wellbore with the upper end of the other thoular member overlapping with the lower end of the carlier expanded tubular member. In this manner amono diameter well bore casing may be formed that includes diameter well bore casing may be formed that includes a further and the collaboration of the diameter well bore casing may be formed that includes a further and the collaboration of the diameter well bore casing may be formed that includes a further and the collaboration of the casing may be formed that includes a collaboration of the co

from flowing backwards into the apparatus.

[0072] After completing the injection of the cement into the annulus, the drilling pipe 30 is then pulled upwairdly out of the wellbore. 12 thereby causing the cementing prober 122. The radial prober 18 to close the sliding sleeve valve 122. The radial prober 18 to close the sliding sleeve valve 122. The radial expansion and plastic deformation of the expandable tubilist member 14 may then be continued by the recumed injection of fluidic material 38 into the apparatus 10. In expansion and plastic deformation of the expandable tubilist member 14 may be provided by pressurizing the bular member 14 may be provided by pressurizing the interior of the apparatus 10 below the expansion cone interior of the apparatus 10 below the expansion cone. 24 and/or by displacing the expansion cone. 24 and/or by displacing the expansion cone.

ball 52 or dard.

Figs. 22a -22b, a hardenable fluidic sealing material 38 such as, for example, cement, may then be injected into the apparatus, through the bypass flow path 124, and oil the apparatus, through the bypass flow path 124, and oil the apparatus, through the pypass flow path 124, and oil the apparatus, through the injected into oil through the float valve 126 into the annulus 128 between the tadially expanded tubular member 22 and the wellbore 12. After the cement 38 has been injected into wellbore 12. After the cement 38 has been injected into the annulus 128, the float valve 126 prevents the cement.

[0070] In an exemplary embodiment, as illustrated in Figs. 21a. 21b, the drill pipe 30 is lowered into the well-bore 12 until the cementing probe 118 stabs into the end 120 of the sliding sleeve valve 122 thereby permitting fluidic materials 38 to bypass around the dark of ball 52. As a result, a bypass flow path 124 is now provided for scallt, a bypass flow path 124 is now provided for cement or other fluidic materials 38 to flow around-the cement or other fluidic materials 38 to flow around-the

mono dismeter wellbore casing.

[0082] In another embodiment the expansion cone assembly includes a first adjustable cone having an exter-

the mono diameter wellbore casing.

[084] In another embodiment the expansion cone assembly includes a first adjustable cone having an external surface adjustable to the diameter of the bell portion of the expandable tubular member and a second adjustion of the expandable to the diameter of the diameter cone having an external surface adjustable to the diameter of the diameter cone surface adjustable to the diameter of the diameter of the diameter of the diameter contexponding to the desired diameter of the

of the expandable tubular member.

[0080] In one embodiment the expansion cone assembly includes one adjustable cone having an external surface adjustable to the diameter of the bell portion of the expandable tubular member; and wherein the external surface of the one adjustable to surface of the one adjustable to the desired diameter of the desired diameter of

noined desired diameter of the mono diameter portion. other distance with the expansion cone assembly adjustsembly through the expandable tubular member for anthe bell portion and for moving the expansion cone asexpansion cone assembly adjusted to the diameter of expandable tubular member a desired distance with the ameter, and an actuator for moving the cone through the member to adjust from the one diameter to the other dibore casing, means for actuating the expandable tubular no diameter casing for forming the mono diameter wellameter corresponding to the desired diameter of the mobular member and adjustable to another expansion di--ut eldsbnsqxe ant ni notitoq lled bebnsqxe as grimnot dismeter of the bell portion of the wellbore casing for to one expansion diameter corresponding to the desired coupled to the upper tubular support member adjustable pandable tubular member, an expansion cone assembly perween the upper tubular support member and the exupper tubular support member for sealing an interface or more cup seals coupled to the extenor surface of the per tubular support member defining a first passage, one diameter wellbore casing. The apparatus includes an upinitial inside diameter to a desired diameter of a mono tically deforming an expandable tubular member from an bodiments, an apparatus for radially expanding and plas-There has been disclosed in the several erricone assembly 16.

with, the expansion cone assembly 16. [0078] In several alternative embodiments, one or more of the conventional commercially available expansion devices available from Weatherdord International Baker Hughes, Halliburton Energy Services, Schlümberger, and/or Enventure Global Technology may be berger, and/or Enventure Global Technology may be berger, and/or Enventure Global Technology may be berger, and/or Enventure.

Cdaring.

In several alternative embodiments, a conventional rotary expansion device, a conventional hydrotoming expansion device may used instead of, or in combination expansion device may used instead of, or in combination

s non-adjustable cone having a fixed diameter corresponding to the desired diameter to the mono diameter

nal surface adjustable to the diameter of the bell portion of the expandable tubular member and collapsible after expanding the bell portion and a second cone having a fixed diameter corresponding to the desired diameter of the mono diameter wellbore casing such that collapsing the first cone effectively adjusts the effective expansion diameter to the fixed diameter of the second cone.

[0083] In another embodiment the expansion cone assembly includes an upper cam assembly coupled to the upper tubular support member includes a tubular base coupled to the upper tubular support member; and a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm defining an inclined surface, a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the tubular support member, and each upper expansion segment movable relative to the inclined surface of one of the plurality of cam arms to adjust the radial position of an eternal surface of the segment to adjust the diameter of the expansion cone assembly, a lower tubular support member defining a second passage fluidicly coupled to the first passage releasably coupled to the upper tubular support member, a lower cam assembly coupled to the lower tubular support member including a tubular base coupled to the lower tubular support member and a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments, wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower. cam assembly; and a plurality of lower expansion cone segments interleaved with cam arms of the lower cam assembly, each lower expansion cone segment pivotally coupled to the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly and each lower expansion segment movable relative to the inclined surface of one of the plurality of cam arms to adjust the radial position of an eternal surface of the segment to adjust the diameter of the expansion cone assembly, wherein the lower expansion cone segments interleave and overlap the upper expansion cone segments and wherein the upper and lower expansion cone segments each approximate an arcuate spherical external surface for plastically deforming and radially expanding the expandable tubular member.

[0084] In another embodiment, an apparatus for radially expanding and plastically deforming an expandable tubular member, is disclosed including a tubular support member, a adjustable expansion cone assembly coupled to the tubular support member, an expandable tubular member coupled to the adjustable expansion cone assembly, means for displacing the adjustable expansion cone assembly relative to the expandable tubular member and means for adjusting the adjustable expansion cone assembly from one- effective- expansion -diameter

to another effective expansion diameter.

[0085] in another embodiment the tubular support member includes an upper tubular support member comprising an internal flange and a lower tubular support. member comprising an internal flange, wherein the expansion cone includes an upper cam assembly coupled to the upper tubular support member including a tubular base coupled to the upper support member and a plurality of cam arms extending from the tubular base in a downward longitudinal direction, each cam arm-defining an inclined surface, a plurality of upper expansion cone segments interleaved with the cam arms of the upper cam assembly and pivotally coupled to the internal flange of the upper tubular support member, a lower cam assembly coupled to the lower tubular support member including a tubular base coupled to the lower tubular support member and a plurality of carmarms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments, wherein the cams arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower cam assembly and a plurality of lower expansion cone segments interleaved with camarms of the lower cam assembly, each lower expansion. cone segment pivotally coupled to the internal flange of the lower tubular support member and mating with the inclined surface of a corresponding one of the cam arms of the upper cam assembly; and wherein the apparatusfurther includes means for releasably coupling the upper tubular support member to the lower tubular support. member and means for limiting movement of the upper tubular support member relative to the lower tubular support member.

[0086] In one alternative embodiment the apparatus for radially expanding and plastically deforming an expandable tubular member further includes means for pivoting the upper expansion cone segments and means for pivoting the lower expansion cone segments.

[0087] In one alternative embodiment the apparatus for radially expanding and plastically deforming an expandable tubular member further includes means for pulling the adjustable expansion cone assembly through the expandable tubular member.

[0088] A adjustable expansion cone assembly is disclosed, that includes an upper cam assembly including a tubular base and a plurality of cam arms extending from the tubular base in a downward longitudinal direction; each cam arm defining an inclined surface; a plurality of upper expansion cone segments interfeaved with the cam arms of the upper cam assembly, a lower cam assembly including a tubular base and a plurality of cam arms extending from the tubular base in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments, wherein the cam arms of the upper cam assembly are interleaved with and overlap the cam arms of the lower

the dismeter of the bell portion and for moving the exsired distance, with the expansion assembly adjusted to assembly, through the expandable tubular member a deofher diameter and an actuator for moving the expansion tubular member to adjust from the one diameter to the eter wellbore casing, means for actuating the expandable of the mono diameter casing for forming the mono diampansion diameter corresponding to the desired diameter pandable tubular member and adjustable to another excasing for forming an expanded bell portion in the exto the desired diameter of the bell portion of the wellboreper adjustable to one expansion diameter corresponding sion assembly coupled to the upper tubular support memmember and the expandable tubular member, an expansealing an interface between the upper tubular support terior surface of the upper tubular support member for inar passage, one or more cup seals coupled to the exincluding an upper tubular support member defining a ameter of a mono diameter wellbore casing is disclosed. member from an initial inside diameter to a desired dibauqiud auq biszticaliy deforming an expandable tubular [0092] An embodiment of an apparatus for radially exthe intermediate portion to the outer portion.

Ing srcuste cylindrical upper and lower surfaces.

[0091] In one embodiment of the adjustable expansion cone sesembly, each upper expansion cone segment is tapered in the longitudinal direction from the intermediate tapered in the cuter portion and each lower expansion.

temal surface.

[0090] In one embodiment of the adjustable expansion cone assembly, each upper expansion cone segment comprises an inner portion defining an arcuste cylindrical lupper surfaces and an arcuste cylindrical lower surfaces and an arcuste cylindrical lower surfaces and an include an inner portion defining arcuste cylindrical lower surfaces, and wherein each lower surfaces, and wherein each lower expansion cone segment include an inner portion defining arcuste cylindrical lower surfaces, an inner portion defining arcuste cylindrical lower surfaces, an intermediate portion defining arcuste cylindrical lower surfaces, an intermediate portion defining arcuste cylindrical lower surfaces.

nober expansion cone segments.

[0089] In one embodiment of the adjustable expansion cone sasembly, the upper and lower expansion cone segments for a cone segments.

cam assembly, a plurality of lower expansion cone segments interleaved with cam arms of the lower cam-assembly, each lower expansion cone segment mating with the inclined surface of a corresponding one of the upper cam assembly, toward or away from the lower expansion cone segments to adjust the radial position of paralog cone segments to adjust the radial position of an external surface of the lower expansion cone segments are expansion cone segments of the lower expansion cone segments. The lower cam assembly ments and means for moving the lower cam assembly many that the radial position of some cone segments of the lower cam assembly many that the radial position of sine externs.

aglustable expansion cone device of an apparatus for radially expanding and plastically defining an expanding to another alternative embodiment forming an expandable tubular member from an initial inside diameter of a mono diameter of a mono diameter wellbore casing, the expansion assembly comprises an wellbore casing, the expansion assembly comprises an wellbore casing, the expandable tubular member to the diameter of the device that is adjustable to the diameter of the device is ameter of the bell portion of the expandable tubular members and wherein the expandance is

60098] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable fubbular, member from an initial inside diameter to a desired diameter of a mono diameter of a mono diameter and wellbore casing, the expansion assembly comprises an adjustable expanded device that is adjustable to the diameter of the bell portion of the expandable tubular member and wherein the one adjustable expander device is also adjustable to the diameter corresponding to the desired diameter of the diameter corresponding to the desired diameter of the mono diameter wellbore casing and sine diameter of the mono diameter device is sined diameter of the mono diameter device and the mono diameter device comprises an anneren the adjustable expander device comprises an wherein the adjustable expander device comprises an wherein the adjustable expander device comprises an

hydrotorning expansion device.

[0097] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing, the expansion assembly comprises an adjustable expander device that is adjustable tubular member and wherein the one adjustable expander device is adjustable to the diameter of the bell portion of the expander device is also adjustable to the diameter of the bell portion of the expander device is and wherein the one adjustable expander device is also adjustable to the diameter of the bell portion of the expander device is

compliant expansion device.

[0096] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter well bore casing, the expansion assembly comprises a

rolary expansion device:

[0995] According to another allemative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing: the expansion assembly comprises.

sion cone device.

[0094] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing, the expansion assembly comprises a

portion of the expandable tubular member.

[0093] According to one alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter well-bore casing, the expansion assembly includes an expan-

pansion assembly through the expandable tubular member for another distance with the expansion assembly adjusted to the desired diameter of the mono diameter οī

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cludes expanding using a compliant expansion device. upper portions of the expandable tubular members informing a casing in a wellbore, expanding the lower and [0114] In an alternative embodiment of the method of cindes expanding using a rotary expansion device:

upper portions of the expandable tubular members informing a casing in a wellbore, expanding the lower and to bothem and to themibodine evidentials in an [E110]

cindes expanding using an expansion cone device. upper portions of the expandable tubular members informing a casing in a wellbore, expanding the lower and [0112] In an alternative embodiment of the method of expanded expandable tubular members

is expanded radially outward in the lower portion of the the top portion of the second expandable tubular member able tubular member to the second diameter of so that per and expanding the top portion of the second expandlower portion of the expanded expandable tubular mempandable tubular member is overlapped by the expanded tubular member so that a top portion of the second expandable tubular member into the expanded expandable ceding paragraph, further includes inserting a second exforming a casing in a wellbore, as described in the preto bontom ant triambodime evide method of the second inside diameter.

ameter; wherein the first inside diameter is larger than the expandable tubular member to a second inside diexpanding and plastically deforming an upper portion of tubular member to a first inside diameter, and radially plastically deforming a lower portion of the expandable. lat member into-the wellbore, radially expanding and iud ju s wellpote, includes inserting an expandable tubu-[0110] In an alternative embodiment a method of a casan adjustable hydroforming expansion device.

cludes expanding the expandable tubular member using -ni bodiem aft inamibodme avitemelle ne nl [6010] an adjustable compliant expansion device.

cludes expanding the expandable tubular member using [8010] In an alternative embodiment the method inan adjustable a rotary expansion device:

cludes expanding the expandable tubular member using [0107]. In an alternative embodiment the method inan adjustable expansion cone device

cindes expanding the expandable tubular member using in an alternative embodiment the method inexpandable tubular member:

ameter as the expanded remaining portion of the first the second expandable tubular member to the same dially expand and plastically deform a second portion of bly is adjusted to the third diameter, and to thereby raditubular member when the adjustable expansion assemand past the portion overlapping with the first expandable semply through the second expandable tubular member ond diameter and moving the adjustable expansion asthe adjustable expansion assembly to adjust to the secmember, activating the effective expansion diameter of below the first portion of the first expandable tubular s first portion of the second expandable tubular member

sensed operating pressure of the injected fluidic material able tubular member and into the wellbore when the exbansion cone assembly relative to the second expandof the tubular support member, displacing the adjustable of the injected fluidic material within a first interior portion tubular support member, sensing the operating pressure able tubular member, injecting a fluidic material into the the first portion thereof overlapping the second expandin the expanded first expandable tubular member with per positioning the second expandable tubular member than the inside diameter of the expandable tubular memexpansion cone assembly having a first diameter smaller bore using a tubular support member and an adjustable porting a second expandable tubular member in the wellscuped in the preceding paragraph, further includes supforming a mono diameter casing in a wellbore, as delo boiltam alt lo inamibodime existinative method of member

form the remaining portion of the expandable tubular diameter, to thereby radially expand and plastically delustable expansion cone assembly is adjusted to the third through the expandable tubular member when the adand moving the adjustable expansion cone assembly sweter swaller than the first effective expansion diameter spie expansion cone assembly to adjust to a second diactivating the effective expansion diameter of the adjustdeform a first portion of the expandable tubular member, able tubular member to radially expand and plastically ond diameter a predetermined distance into the expandthe adjustable expansion cone assembly having the secintenor portion of the tubular support member, moving terial exceeds a predetermined level within the second the sensed operating pressure of the injected fluidic maside diameter of the expandable tubular member when cone assembly to a second diameter larger than the insective expansion diameter of the adjustable expansion portion of the tubular support member, adjusting the etof the injected fluidic material within a second intenor bular support member, sensing the operating pressure determined level within the first interior portion of the tupressure of the injected fluidic material exceeds a preber and into the wellbore when the sensed operating cone assembly relative to the expandable tubular memsupport member, displacing the adjustable expansion fluidic material within a first interior portion of the tubular member-sensing the operating pressure of the injected ber, injecting a fluidic material into the tubular support than the inside diameter of the expandable tubular memexpansion cone assembly having a first diameter smaller eldstaulbs, na bna redmem hoqqua raludut a gnigu erod supporting a first expandable tubular member in the wellforming a mono diameter casing in a wellbore includes lo bottem aft to inembodiment of the method of

dudes expanding using a hydrotoming expansion deupper portions of the expandable tubular members informing a casing in a wellbore, expanding the lower and [CITS] In an alternative embodiment of the method of

vice.

also adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing and wherein the adjustable expander device includes an adjustable rotary expansion device.

[0100] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing, the expansion assembly comprises an adjustable expander device that is adjustable to the diameter of the bell portion of the expandable tubular member and wherein the one adjustable expander device is also adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing and wherein the adjustable expander device includes an adjustable compliant expansion device:

[0101] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing, the expansion assembly comprises an adjustable expander device that is adjustable to the diameter of the bell portion of the expandable tubular member and wherein the one adjustable expander device is also adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing and wherein the adjustable expander device includes an adjustable hydroforming expansion device.

[0102] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter wellbore casing, wherein the expansion assembly includes a first adjustable expander device adjustable to the diameter of the bell portion of the expandable tubular member and second adjustable expander device adjustable to the diameter corresponding to the desired diameter of the mono diameter wellbore casing.

[0103] According to another alternative embodiment of an apparatus for radially expanding and plastically deforming an expandable tubular member from an initial inside diameter to a desired diameter of a mono diameter well bore casing, wherein the expansion assembly includes a first adjustable expander device adjustable to the diameter of the bell portion of the expandable tubular member and collapsible after expanding the bell portion and a second expander device having a fixed diameter corresponding to the desired diameter of the mono diameter well bore casing such that collapsing the first adjustable expander device effectively adjusts the effective expansion diameter to the fixed diameter of the second expander device.

[0104] A method of forming a mono diameter casing in a wellbore is disclosed, including supporting a first expandable tubular member in the wellbore using a tubular support member and an adjustable expansion assembly having a first diameter smaller than the inside diameter of the expandable tubular member injecting a fluidic ma-

terial into the tubular support member, sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member, displacing the adjustable expansion assembly relative to the expandable tubular member and into the wellbore when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member, sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member, adjusting the effective expansion diameter of the adjustable expansion assembly to a second diameter larger than the inside diameter of the expandable tubular member when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member, moving the adjustable expansion assembly having the second diameter a predetermined distance into the expandable tubular -member to radially expand and plastically deform a first portion of the expandable tubular member, activating the effective expansion diameter of the adjustable expansion assembly to adjust to a second diameter smaller than the first effective expansion diameter and moving the adjustable expansion assembly through the expandable tubular member when the adjustable expansion assembly is adjusted to the third diameter, to thereby radially expand and plastically deform the remaining portion of the expandable tubular member.

30 [0105] In an alternative embodiment, the method of forming a mono diameter wellbore casing as in the paragraph above that further includes supporting a second expandable tubular member in the wellbore using a tubular support member and an adjustable expansion assembly having a first diameter smaller than the inside diameter of the expandable tubular member, positioning the second expandable tubular member in the expanded first expandable tubular member with the first portion thereof overlapping the second expandable tubular member, injecting a fluidic material into the tubular support member, sensing the operating pressure of the injected fluidic material within a first interior portion of the tubular support member, displacing the adjustable expansion assembly relative to the second expandable tu-45 bular member and into the well bore when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the first interior portion of the tubular support member, sensing the operatingpressure of the injected fluidic material within a second interior portion of the tubular support member, adjusting the effective expansion diameter of the adjustable expansion assembly to the second diameter when the sensed operating pressure of the injected fluidic material. exceeds a predetermined level within the second interior portion of the tubular support member, moving the adjustable expansion assembly having the second diameter a predetermined distance into the second expandable tubular member to radially expand and plastically deform

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exceeds a predetermined level within the first interior portion of the tubular support member, sensing the operating pressure of the injected fluidic material within a second interior portion of the tubular support member, adjusting the effective expansion diameter of the adjustable expansion cone assembly to the second diameter when the sensed operating pressure of the injected fluidic material exceeds a predetermined level within the second interior portion of the tubular support member, moving the adjustable expansion cone assembly having the second diameter a predetermined distance into the second expandable tubular member to radially expand and plastically deform a first portion of the second expandable tubular member below the first portion of the first expandable tubular member, activating the effective expansion diameter of the adjustable expansion cone assembly to adjust to the second diameter and moving the adjustable expansion cone assembly through the second expandable tubular member and past the portion overlapping with the first expandable tubular member when the adjustable expansion cone assembly is adjusted to the third diameter, and to thereby radially expand and plastically deform a second portion of the second expandable tubular member to the same diameter as the expanded remaining portion of the first expandable tubular member.

Claims

 An apparatus for radially expanding and plastically deforming an expandable tubular member (14), comprising:

> a support member (30); an adjustable expansion cone assembly (16) coupled to the support member (30); an expandable tubular member (14) coupled to the adjustable expansion cone assembly (16), characterised by:

means for displacing the adjustable expansion cone assembly (16) relative to the expandable tubular member (14) and the support member (30); and means for adjusting the adjustable expansion cone assembly (16) from one effective expansion diameter to another effective expansion diameter.

The apparatus of claim 1, wherein the support member (30) comprises an upper support member (94) comprising an internal flange (94d) and a lower support member (100) comprising an internal flange (100d); and wherein the expansion cone (16) comprises:

an upper cam assembly (90) coupled to the upper support member (94) comprising:

a tubular base (40a) coupled to the upper support member (94); and a plurality of cam arms (40c) extending from the tubular base (90a) in a downward longitudinal direction; each cam arm defining an inclined surface;

a plurality of upper expansion cone segments (96) interleaved with the cam arms (90c) of the upper cam assembly (90) and pivotally coupled to the internal flange (94d) of the upper support member (94);

a lower cam assembly coupled to the lower support member (100) comprising:

a tubular base (92a) coupled to the lower support member (100); and a plurality of cam arms (92c) extending from the tubular base (92a) in an upward longitudinal direction, each cam arm defining an inclined surface that mates with the inclined surface of a corresponding one of the upper expansion cone segments (96);

wherein the cams arms (90c) of the upper cam assembly (90) are interleaved with and overlap the cam arms (92c) of the lower cam assembly (92); and

a plurality of lower expansion cone segments (98) interleaved with cam arms (92c) of the lower cam assembly (92), each lower expansion cone segment (98) pivotally coupled to the internal flange (100d) of the lower support member (100) and mating with the inclined surface of a corresponding one of the cam arms (90c) of the upper cam assembly (90); and wherein the apparatus further comprises:

means for releasably coupling the upper support member (94) to the lower support member (100); and means for limiting movement of the upper support member (94) relative to the lower support member (100).

3. The apparatus of claim 1, further comprising:

means for pivoting the upper expansion cone segments (96); and means for pivoting the lower expansion cone segments (98).

4. The apparatus of claim 1, further comprising:

means for pulling the adjustable expansion cone assembly (16) through the expandable tubular member (14).

lower and upper portions (22, 28) of the expandable tubular members (188, 18b) comprises expanding using a hydroforming expansion device (24)

Patentansprüche

Vorrichtung zum radialen Aufweiten und plastischen
Vertormen eines ausdehnbaren rohndimigen Teils
(† ½), umfassend:

ein Trageteil (30); eine einstellbare Ausdehnkonus-Baugruppe (16), die mit dem Trageteil (30) verbunden ist, ein ausdehnbares rohrförmiges Teil (14), das mit der einstellbaren Ausdehnkonus-Baugruppe (16) verbunden ist, gekennzeichnet durch;

Trageteil (30); und Ausdehnbare rohrförmige Teil (14) und das Ausdehnbare rohrförmige Teil (14) und das Mittel zum Verschieben der einstellbaren

trägeren (30); und Mittel zum Einsteilbaren Ausdehnkonne-Baugruppe (16) von einem effektiven Ausdehnungsdurchmesser auf einen -anderen effektiven Ausdehnungs-

Vornchtung nach Ansprüch 1, wobei das Trageteil (30) ein oberes Trageteil (94) umfasst, das einen ihneren Flansch (94d) enthält, und ein unteres Trageteil (100), das einen inneren Flansch (100d) enthält; und wobei der Ausdehnikonus (16) umfasst:

durchmesser,

eine obere Nockenbaugruppe (90), die mit dem oberen Trageteil (94) verbunden ist, umfassend:

eine rohrförmige Basis (40s), die mit dem oberen Trageteil (94) verbunden ist und eine Anzahl Wockenarme (40c), die sich von der rohrförmigen Bäsis (90ä) in einer Längsnchtung nach unten erstrecken wobei jeder Nockenarm-eine geneigte Ober-

eine Anzahl oberer Ausdehnkonussegmente (96), die mit den Nockenarmen (90c) der oberen Nockenbaugruppe (90) verschachtelt sind und schwenkbar an den inneren Flansch (94d) des

oberen Tragefeils (94) gekoppelt sind; eine untere Mockenbaugruppe; die mit dem unteren Tragefeil (100) verbunden ist; umfassend:

eine rohrformige Basis (92a), die mit dem unteren Trageteil (100) gekoppelt ist, und eine Anzahl Nockenarme (92c), die sich von der Trohrformigen Basis (92a) in einer der Trohrformigen Basis (92a) in einer

5. A method of forming a casing in a wellbore (12), com-

pardable tubular member (14),

characterised by:

diameter.

positioning the expansion device and the expandable fubular member (14) into the wellbore

lowering the expansion device out of an end of the expandable jubular member (14) within the wellbore (12):

radially expanding and plastically expanding and plastically expands to the expandable tubular lower portion (S2a) to the expandable tubular member (10) is of (11) is of (12) insing

the expansion device; and redically deforming an radially expanding and plastically deforming an upper portion (28a) of the expandable tubular member (14) to a second incide diameter (ID₁) is expansion device; wherein the first instaing the expansion device; wherein the first instance diameter is larger than the second inside

6. The method of claim 5 further comprising :

inserting a second expandable tubular member (18b), into the expanded expandable tubular member (18b) so that a top portion (28b) of the second expandable tubular member (18b) is second expandable tubular member of the expandable tubular member of tubular

(183); and expanding the top portion (28b) of the second expanding the top portion (28b) of the second diameter (10₁) so that the top portion (28b) of the second expandable (19b) in the second expandable (19b) in the expandable expanded expanded (22a) of the expandable expanded expandable expanded expandable expanded expandable expandabl

tubular member (18a):

The method of claim 5, wherein the expanding the lower and upper portions (22, 28) of the expandable

nejud su exbansion cone device (46).

Tubular members-(1881, 18b) comprises expanding:

The method of claim 5, wherein the expanding the lower and upper portions (22, 28) of the expanding the fubular members (18a, 18b) comprises expanding so using a rotary expansion device.

9: The method of claim 5, wherein the expanding the lower and upper portions (22, 28) of the expanding the lower and upper portions (28, 18), compress expanding by tubuist members (188, 189), compress expanding significant

10. The method of claim 5, wherein the expanding the

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bei jeder Nockenarm eine geneigte Oberfläche bestimmt, die mit der geneigten. Oberfläche eines zugeordneten oberen Ausdehnkonussegments (96) zusammenpasst,

wobei die Nockenarme (90c) der oberen Nokkenbaugruppe (90) mit den Nockenarmen (92c) der unteren Nockenbaugruppe (92) verschachtelt sind und sie überlappen; und eine Anzahl unterer Ausdehnkonussegmente (98), die mit den Nockenarmen (92c) der unteren Nockenbaugruppe (92) verschachtelt sind, wobei jedes untere Ausdehnkonussegment (98) schwenkbar mit dem inneren Flansch (100d) des unteren Trageteils (100) verbunden ist und mit der geneigten Öberfläche eines zugeordneten Nockenarms (90c) der oberen Nockenbaugruppe (90) zusammenpasst; und worin die Vörrichtung ferner umfasst:

Mittel zum lösbaren Verbinden des oberen Trageteils (94) und des unteren Trageteils (100); und

Mittel zum Begrenzen der Bewegung des oberen Trageteils (94) gegen das untere Trageteil (100).

3. Vorrichtung nach Anspruch 1, zudem umfassend:

Mittel zum Schwenken der oberen Ausdehnkonussegmente (96); und Mittel zum Schwenken der unteren Ausdehnko-

mittel zum Schwenken der unteren Ausdehnkonussegmente (98).

4. Vornchtung nach Anspruch 1, zudem umfassend:

Mittel zum Ziehen der einstellbaren Ausdehnkonus-Baugruppe (16) durch das ausdehnbare röhrförmige Teil (14).

 Verfahren zum Ausbilden eines Fütterrohrs in einem Bohrloch (12), umfassend:

> das Anordnen einer Ausdehnvorrichtung innerhalb eines ausdehnbaren rohrförmigen Teils. (14), gekennzeichnet durch:

> > das Anordnen der Ausdehnvorrichtung und des ausdehnbaren rohrförmigen Teils (14) in dem Bohrloch (12):

das Absenken der Ausdehnvorrichtung aus einem Ende des ausdehnbaren rohrförmigen Teils (14) hinaus in das Bohrloch (12); das radiale Ausdehnen und plastische Verformen eines unteren Abschnitts (22a) des ausdehnbaren rohrförmigen Teils (14) auf einen ersten Innendurchmesser (ID₂) mit

Hilfe der Ausdehnvorrichtung, und das radiale Ausdehnen und plastische Verformen eines oberen Abschnitts (28a) des ausdehnbaren rohrförmigen Teils (14) auf einen zweiten Innendurchmesser (ID₁) mit Hilfe der Ausdehnvorrichtung, wobei der erste Innendurchmesser größer ist als der zweite Innendurchmesser.

6. Verfahren nach Anspruch 5; zudem umfassend:

das Einsetzen eines zweiten ausgehnbaren rohrförmigen Teils (18b) in das aufgeweitete ausdehnbare rohrförmige Teil (18a), so dass ein oberer Abschnitt (28b) des zweiten ausdehnbaren rohrförmigen Teils (18b) vom ausgeweiteten unteren Abschnitt (22a) des aufgeweiteten ausdehnbaren rohrförmigen Teils (18a) überlappt wird; und

das Ausdehnen des oberen Abschnitts (28b) des zweiten ausdehnbaren rohrförmigen Teils (18b) auf den zweiten Durchmesser (ID₁), so dass der obere Abschnitt (28b) des zweiten ausdehnbaren rohrförmigen Teils (18b) radial nach außen in den ausgeweiteten unteren Abschnitt (22a) des aufgeweiteten ausdehnbaren rohrförmigen Teils (18a) ausgedehnt wird.

- Verfahren nach Anspruch 5, wobei das Ausdehnen der unteren und oberen Abschnitte (22, 28) der ausdehnbaren rohrformigen Teile (18a, 18b) das Ausdehnen mit Hilfe einer Ausdehnkonusvorrichtung (16) umfasst.
- Verfahren nach Anspruch 5, worin das Ausdehnender unteren und oberen Abschnitte (22, 28) der ausdehnbaren rohrförmigen Teile (18a, 18b) das Ausdehnen mit Hille einer drehbaren Ausdehnvorrichtung umfasst.
 - Verfahren nach Anspruch 5, worn das Ausdehnen der unteren und oberen Abschnitte (22, 28) der ausdehnbaren rohrformigen Teile (18a, 18b) das Ausdehnvordehnen mit Hilfe einer nachgiebigen Ausdehnvorrichtung umfasst.
 - Verfähren nach Anspruch 5, worin das Ausdehnen der unteren und oberen Abschnitte (22, 28) der ausdehnbaren rohrförmigen Teile (18a, 18b) das Ausdehnen mit Hilfe einer Hydroforming-Ausdehnvornchtung (24) umfasst.

Revendications

 Dispositif pour développer radialement et déformer plastiquement un élément tubulaire extensible (14), comprenant :

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comprend en outre: came supérieur (90); et dans lequel le dispositif qe csibe (80c) collesbouqsut de Lensemple de a secondistit avec la surface inclinée d'un bras tə (00t) nuənətni hoqquə əb tnəmələ i əb (b00t) (89) étant couplé à pivotement à la bride interne chaque segment de cône d'expansion intérieur me (92c) de l'ensemble de came inférieur (92), inférieurs (98) entrelacés avec des bras de caune pluralité de segments de cône d'expansion

port à l'élément de support inténeur (100). l'élément de support supérieur (94) par rapun moyen pour limiter le mouvement de ment de support inférieur (100); et -biel 6 (46) nueneque moqque eb fremelel un moyen pour coupler de manière libérable

: entro 3. Dispositif selon la revendication 1, comprenant en

cone d'expansion infeneurs (98), un moyen pour faire pivoter les segments-de cone d'expansion supérieurs (96) ; et un moyen pour faire pivoter les segments de

extensible (14). pansion réglable (16) à travers l'élément tubulaire outre un moyen pour tirer l'ensemble de cone d'ex-Dispositif selon-la revendication 1, comprenant en

lorage (12); comprenant les opérations consistant Procédé de formation d'un tubage dans un puits de

d'un élément tubulaire extensible (14), positionner un dispositif d'expansion à l'inténeur

caractérisé par les opérations consistant à

tubulaire extensible (14) dans le puits de forage positionnet le dispositif d'expansion et l'élément

mètre intérieur (ID2) en utilisant le dispositif bulaire extensible (14) jusqu'à un premier dianent une partie inférieure (22a) de l'élément tudévelopper radialement et déformer plastiquemité de l'élément tubulaire extensible (14) ; de forage (12) en le faisant soitir par une extréabaisser le dispositif d'expansion dans le puits

plus grand que le deuxième diamètre intérieur. d'expansion, le premier diamètre intérieur étant diamètre intérieur (ID₁) en utilisant le dispositif tubulaire extensible (14) jusqu'à un deuxième ment une partie supérieure (28a) de l'élément développer radialement et déformer plastiqued'expansion; et

> (ensemble de cône d'expansion réglable (16); un élément tubulaire extensible (14) couple à couplé à l'élément de support (30); un ensemble de cone d'expansion réglable (16) un élément de support (30);

caractérisé par:

ment de support (30); et Pélément tubulaire extensible (14) et à l'éléne d'expansion réglable (16) par rapport à nu woken bont déplacer l'ensemble de cô-

d'expansion effectif. d'expansion effectif à un autre diamètre d'expansion réglable (16) d'un diamètre un moyen pour régler l'ensemble de cône

cone d'expansion (16) comprend : prenant une bride interne (100d), et dans lequel le -moo (001) rueneini hoqque ab inamele nu ta (b46) port supérieur (94) comprenant une bride interne ment de support (30) comprend un élément de sup-2. Dispositif selon la revendication 1, dans lequel l'élé-

comprenants l'élément so support (64) ineuedns un ensemble de came supeneur (90) couple à

anusce iuciuee: pas, chaque bras de came définissant une une direction longitudinale orlentée vers le dant depuis la base tubulaire (90a) dans une pluralité de bras de came (40c) s'étenment de support supérient (94); et une base tubulaire (40a) couplée à l'élé-

ment de support inférieur (100) comprenant : un ensemble de came inférieur couplé à l'éléde l'élément de support supérieur (94); et couplés à pivotement à la bride interne (94d) me (90c) de l'ensemble de came supérieur (90) enbeuenta (86) entrefacés avec les bras de caune pluralité de segments de cône d'expansion

; (86) sineineque parmi les segments de cône d'expansion tace inclinée d'un segment correspondant surace jucjinée dul s'accouple avec la surnaut, chaque bras de came définissant une une direction longitudinale orientee vers le dant depuis la base tubulaire (92a) dans une pluralité de bras de came (92c) s'étennent de support intérieur (100); et une base tubulaire (92a) couplée à l'élé-

semble de came inférieur (92); et et chevauchent les bras de came (92c) de l'enple de came supérieur (90) sont entrelacés avec dans lequel les bras de came (90c) de l'ensem-

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EP 1 549 824 B1

EP 1 549 824 B1

36

6. Procédé selon la revendication 5, comprenant en-

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l'insertion d'un deuxième élément tubulaire extensible (18b) dans l'élément tubulaire extensible étendu (18a) de telle manière qu'une partie supérieure (28b) du deuxième élément tubulaire extensible (18b) est recouverte par la partie inférieure étendue (22a) de l'élément tubulaire extensible étendu (18a); et le développement de la partie supérieure (28b) du deuxième élément tubulaire extensible (18b) jusqu'au deuxième diamètre (ID1) de telle manière que la partie supérieure (28b) du deuxième. élément tubulaire extensible (18b) est étendue 15 radialement vers l'extérieur dans la partie inférieure étendue (22a) de l'élément tubulaire extensible étendu (18a).

7. Procédé selon la revendication 5, dans lequel le dé-20 veloppement des parties inférieure et supérieure (22, 28) des éléments tubulaires extensibles (18a, 18b) comprend le fait de développer en employant un dispositif de cône d'expansion (16).

8. Procédé selon la revendication 5, dans lequel le développement des parties inférieure et supérieure (22, 28) des éléments tubulaires extensibles (18a, 18b) comprend le fait de développer en employant un dispositif d'expansion rotatif.

9. Procédé selon la revendication 5, dans lequel le développement des parties inférieure et supérieure (22, 28) des éléments tubulaires extensibles (18a, 18b) comprend le fait de développer en employant 35

un dispositif d'expansion souple.

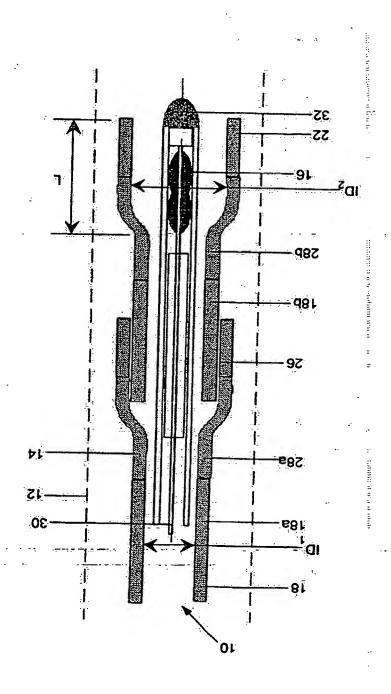
10. Procédé selon la revendication 5, dans lequel le développement des parties inférieure et supérieure (22, 28) des éléments tubulaires extensibles (18a, 18b) comprend le fait de développer en employant un dispositif d'expansion par hydroformage (24).

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Fig. 1



EP 1 549 824 B1

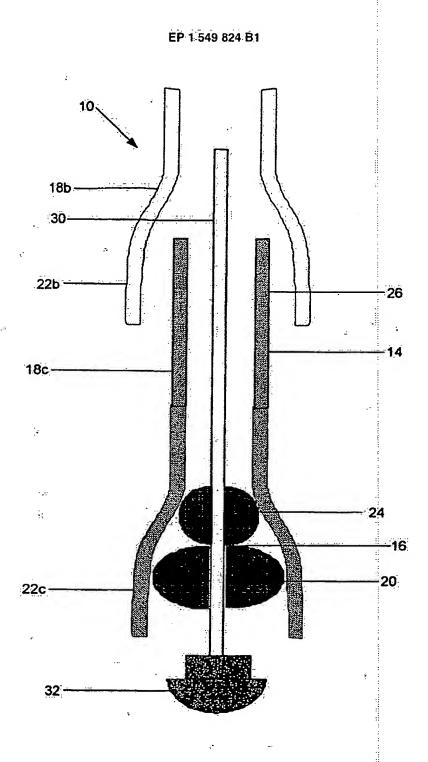
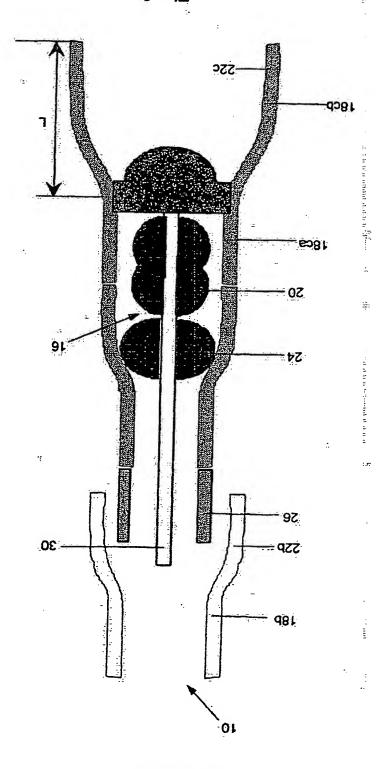


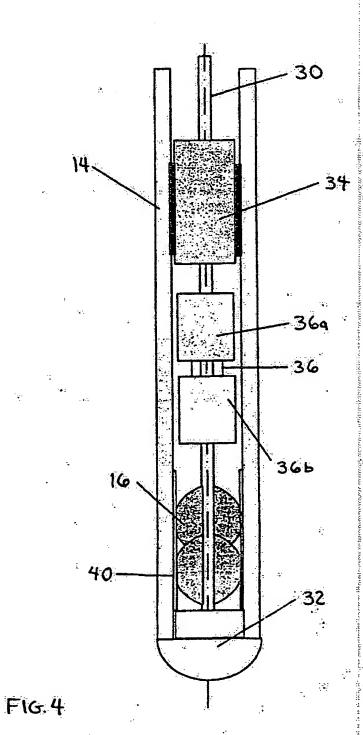
Fig. 2

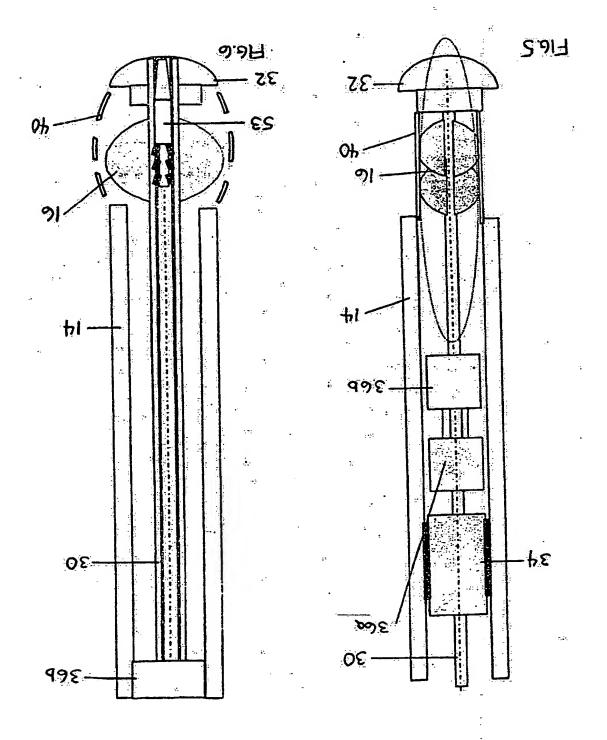


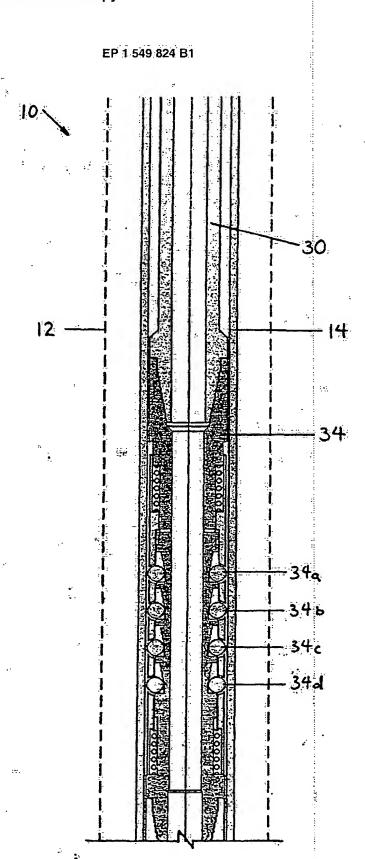


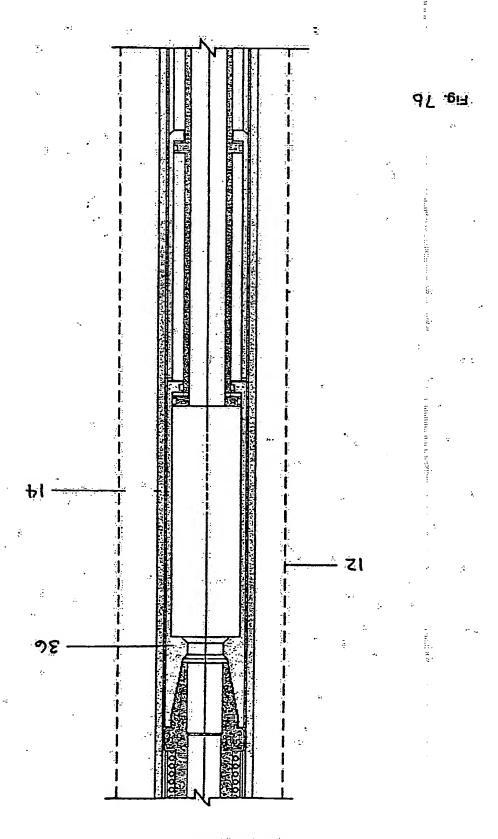
EP 1 549,824 B1

EP 1 549 824 B1









Eb 1 249 824 B1

EP 1 549 824 B1

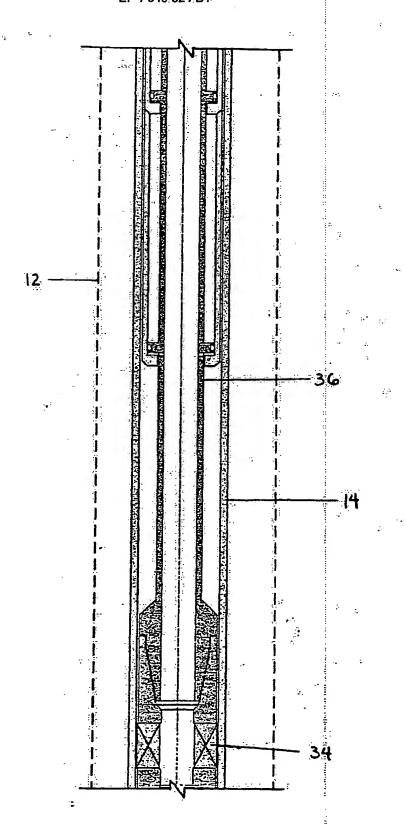
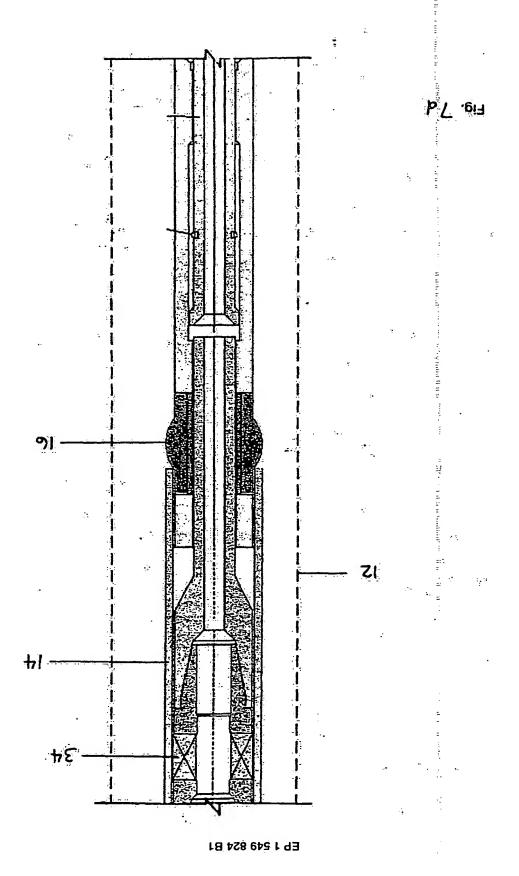


Fig 7_C



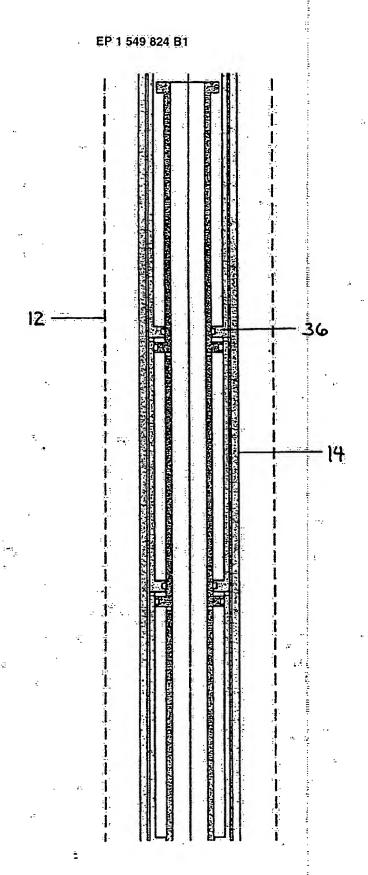
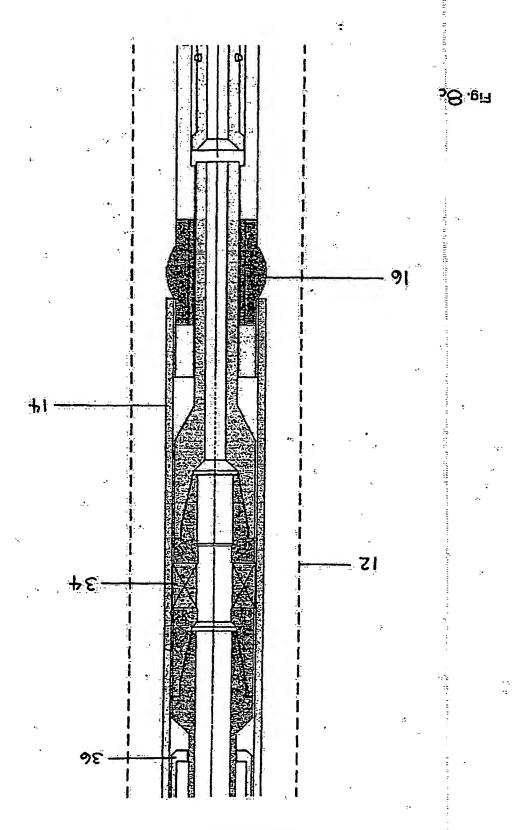


Fig. 8b



Eb 1 246 854 B1

EP 1 549 824 B1

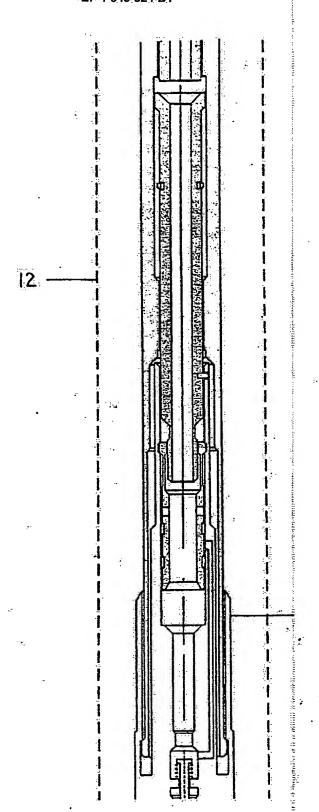
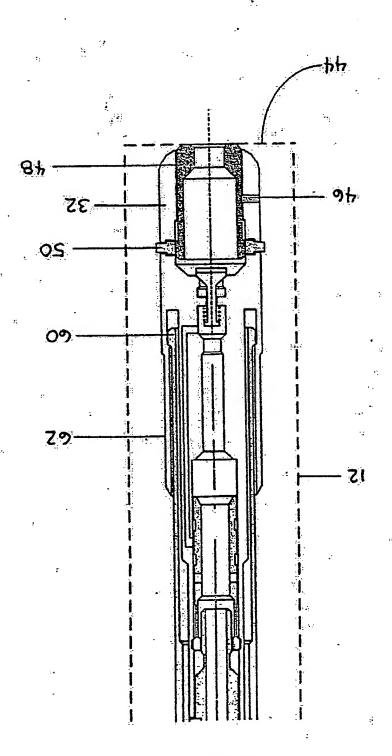


Fig. 8d



Eb 1 249 854 B1

EP 1 549 824 B1

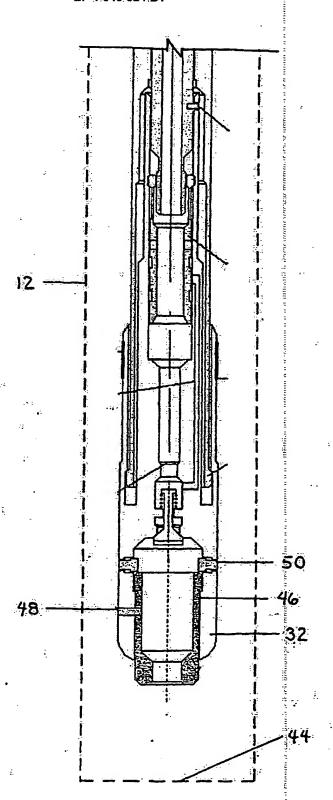
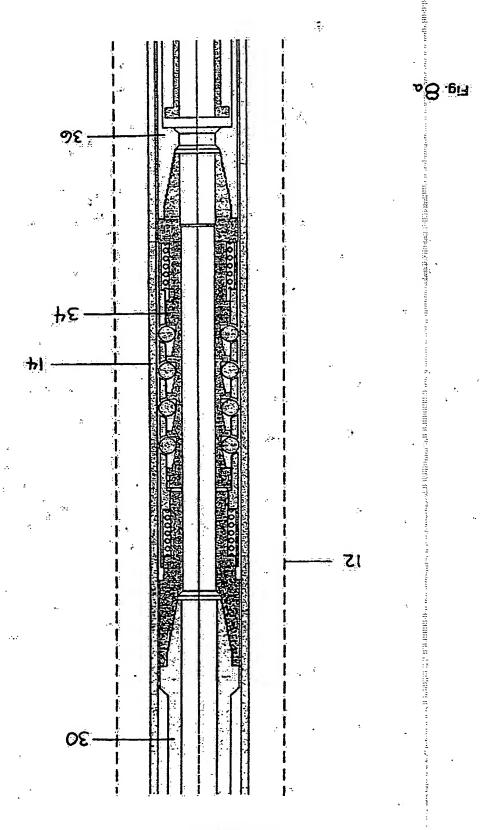
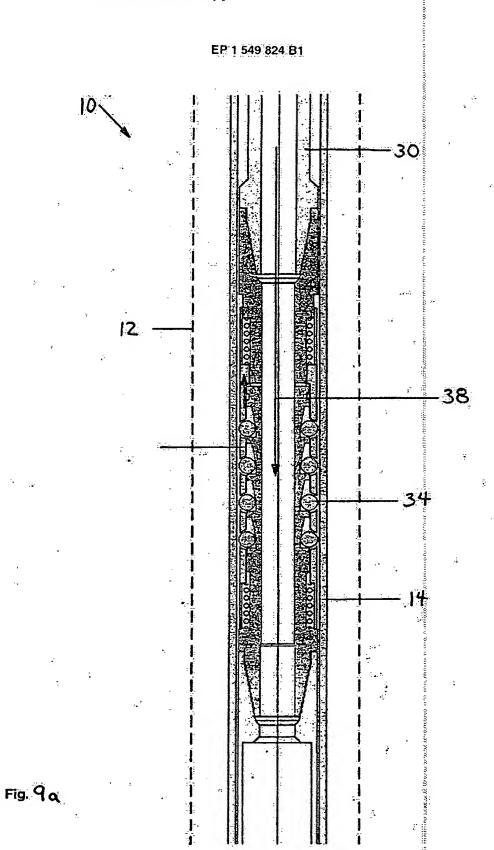
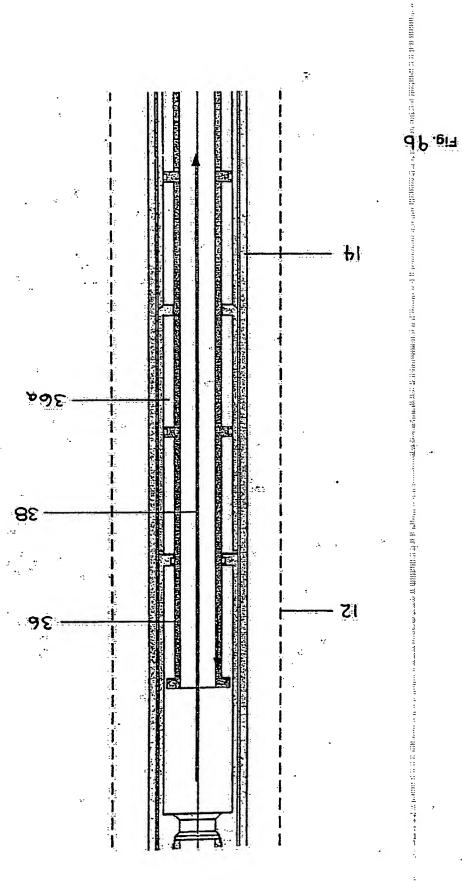


Fig. 7e



EP 1 549 824 B1





EP 1 549 824 B1

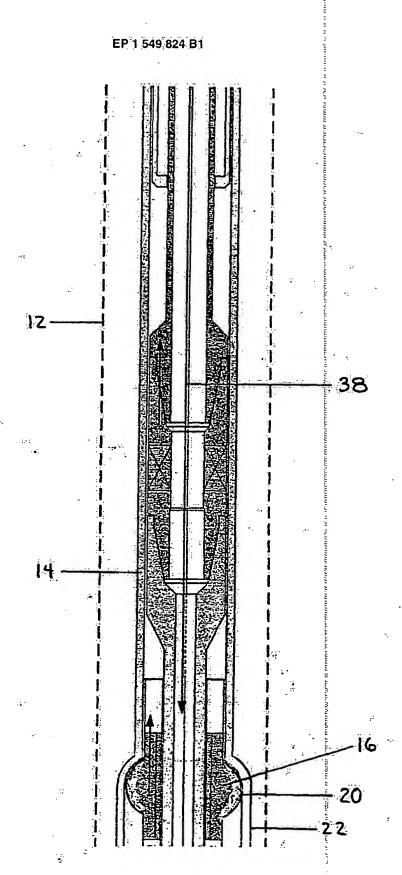
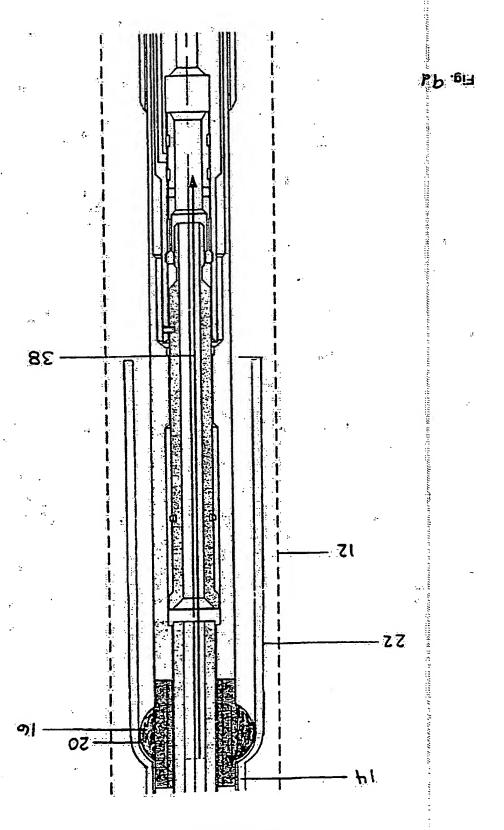


Fig. 9c



EP 1 549 824 B1

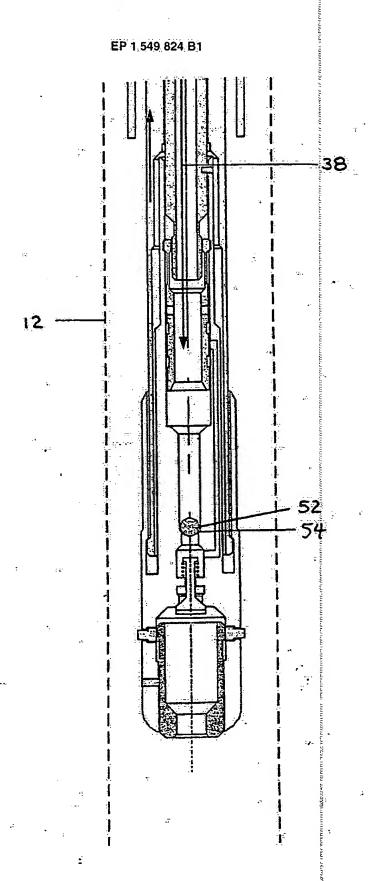
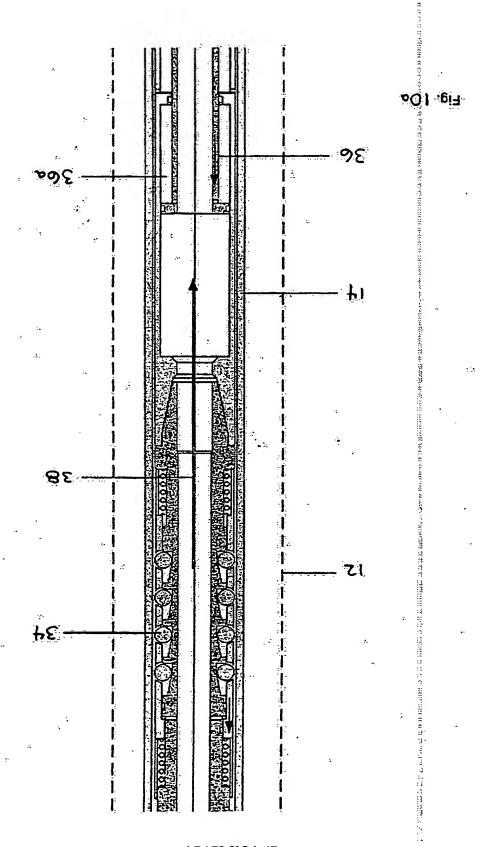
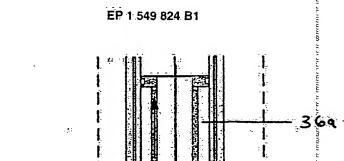


Fig. 9e



FP 1 549 824 B1





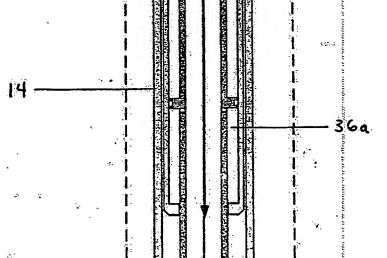
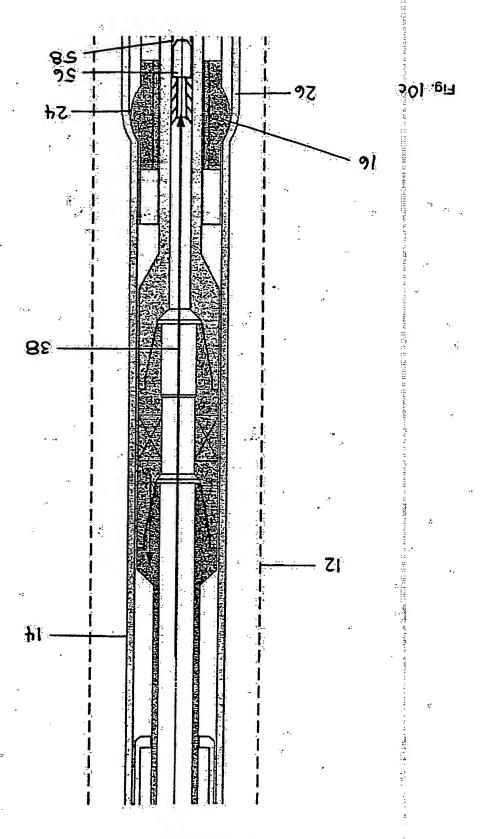


Fig. 10b

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Eb 1 248 854 B1

EP 1 549 824 B1

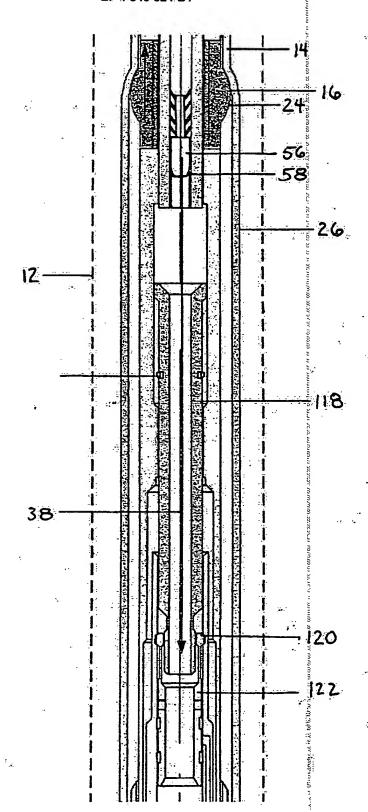
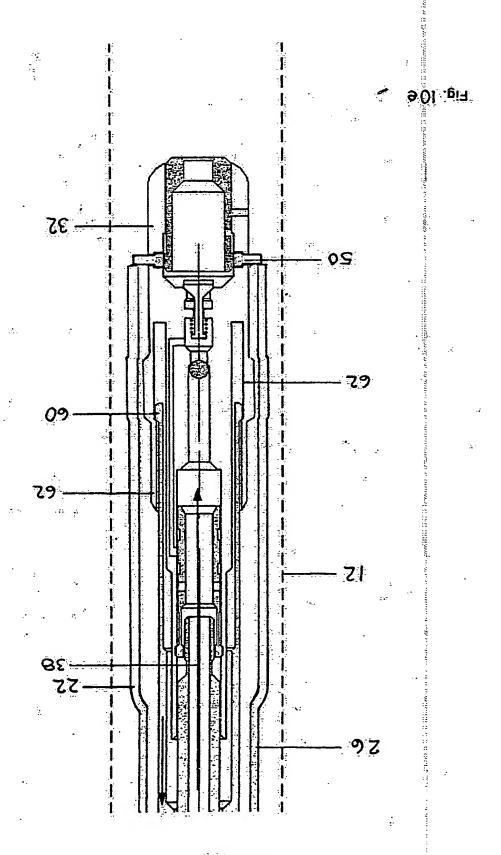


Fig. 10d



EP 1 549 824 B1

EP 1.549.824 B1



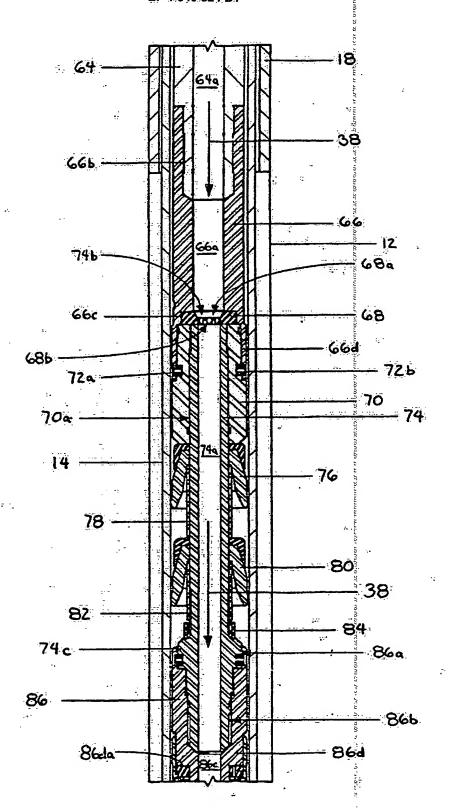
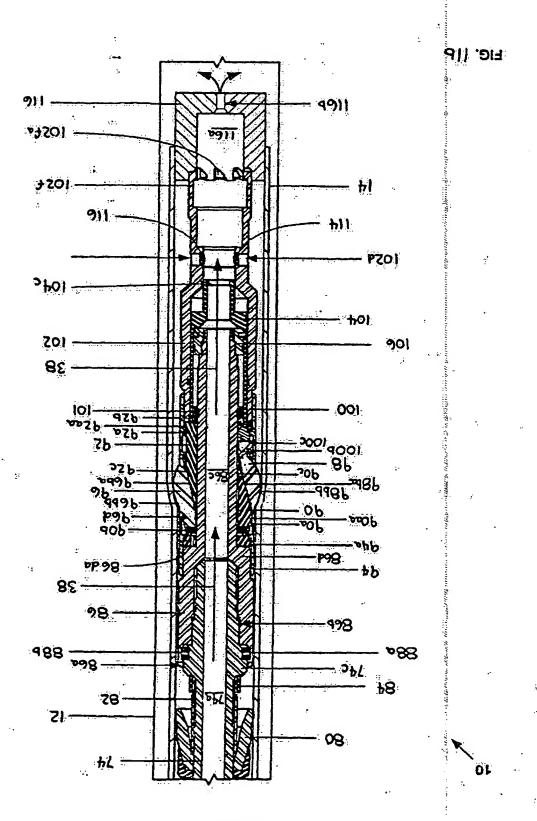


FIG. 11a



Eb 1 246 854 B1

EP 1 549 824 B1



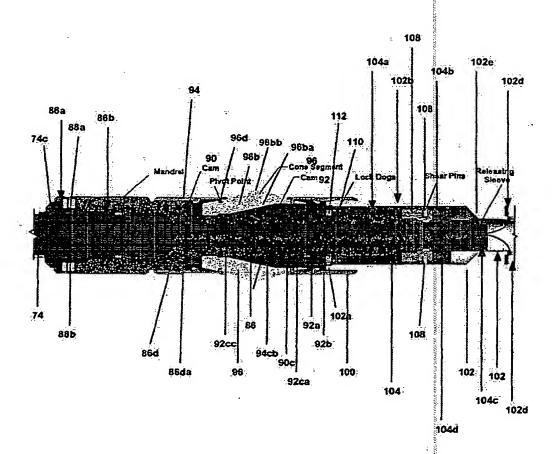
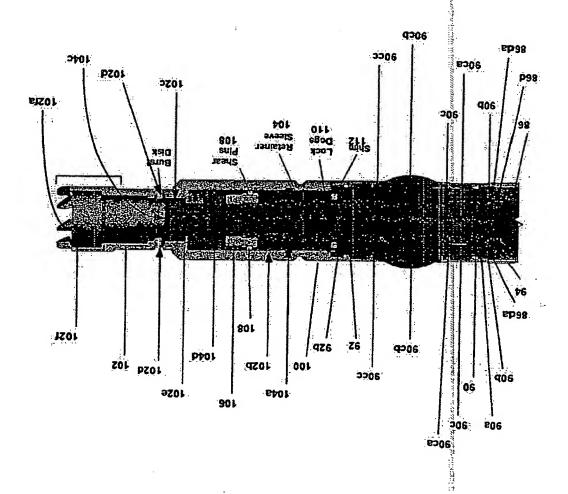


FIG. 12

FIG. 13



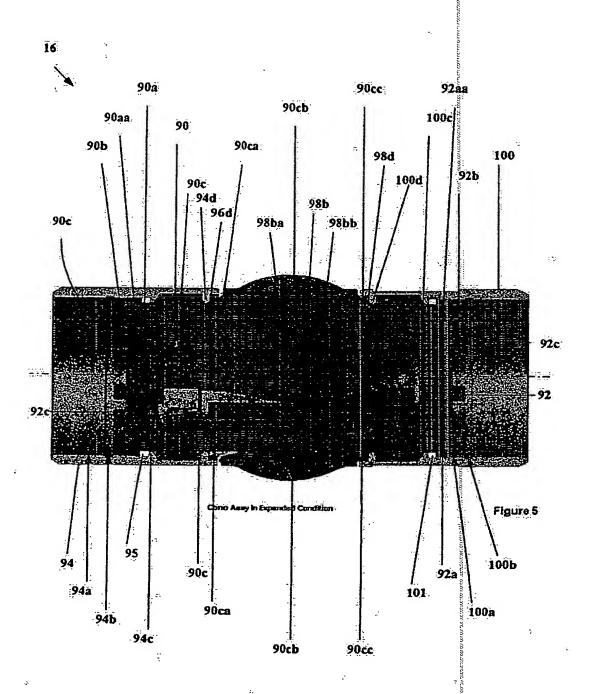
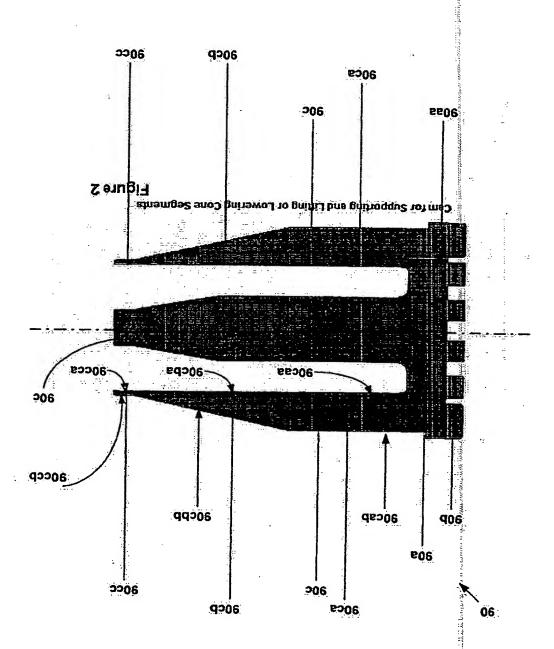


FIG. 14

FIG. 15



EP 1 549 824 B1

92

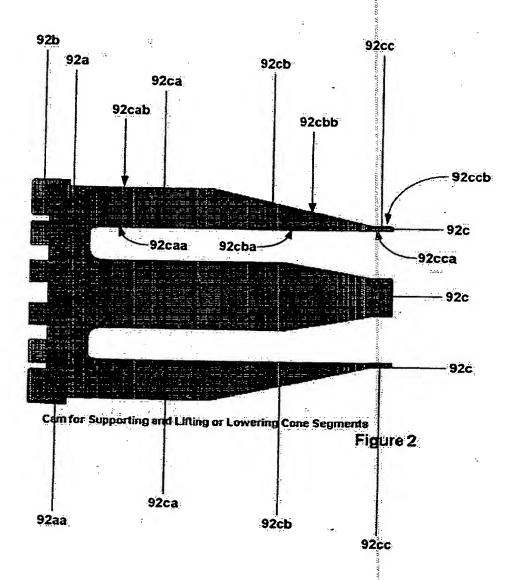
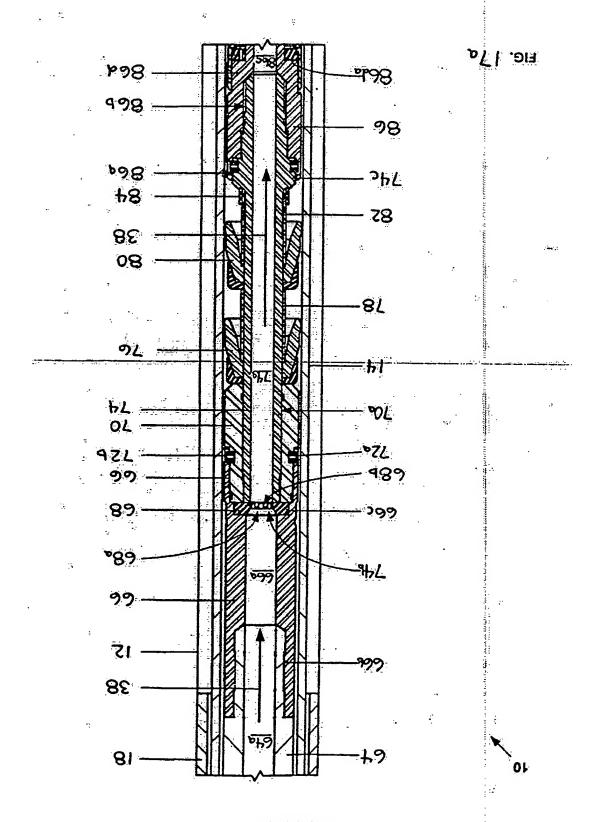


FIG. 16



EP 1 549 824 B1

EP 1 549 824 B1

10

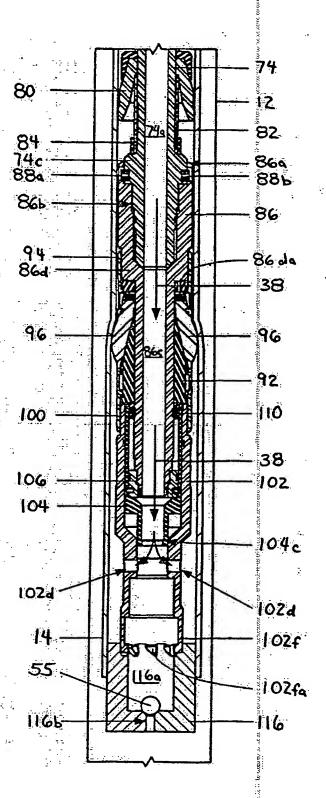
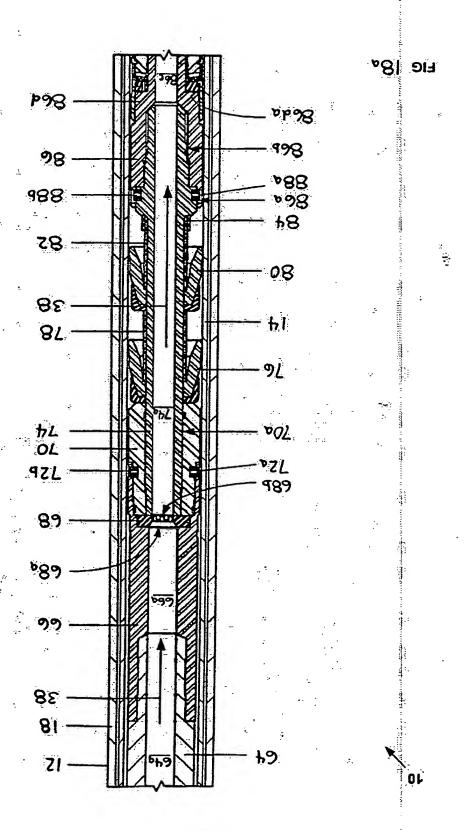


FIG. 176



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Eb 1 246 854 B1

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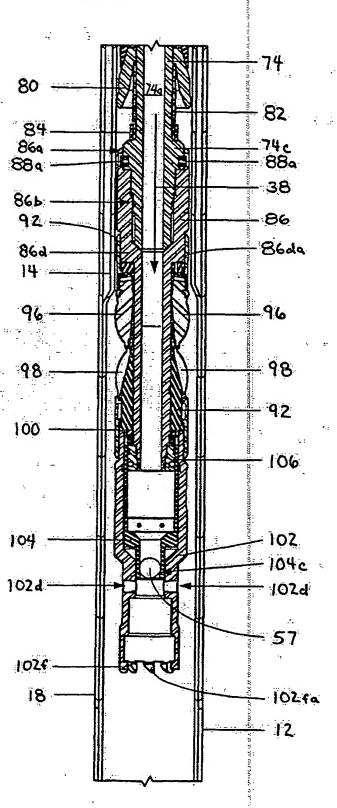
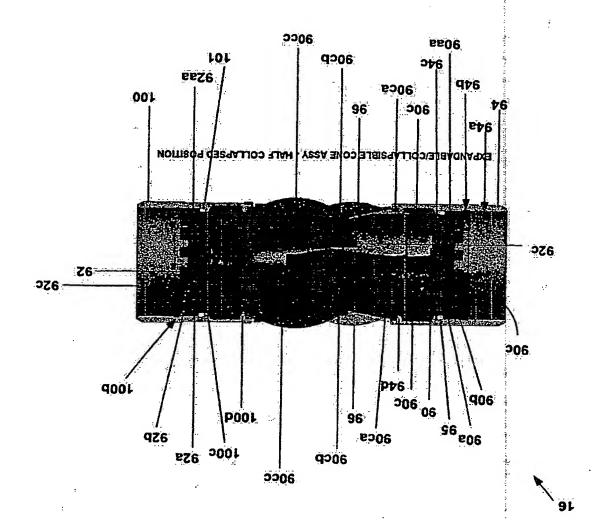
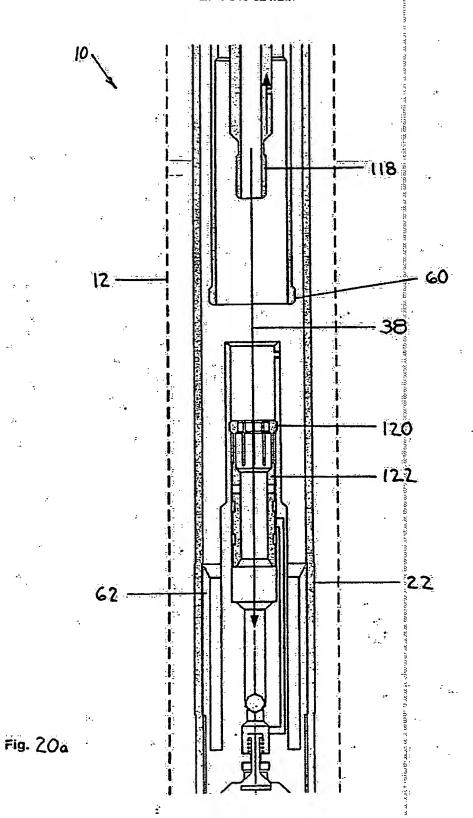


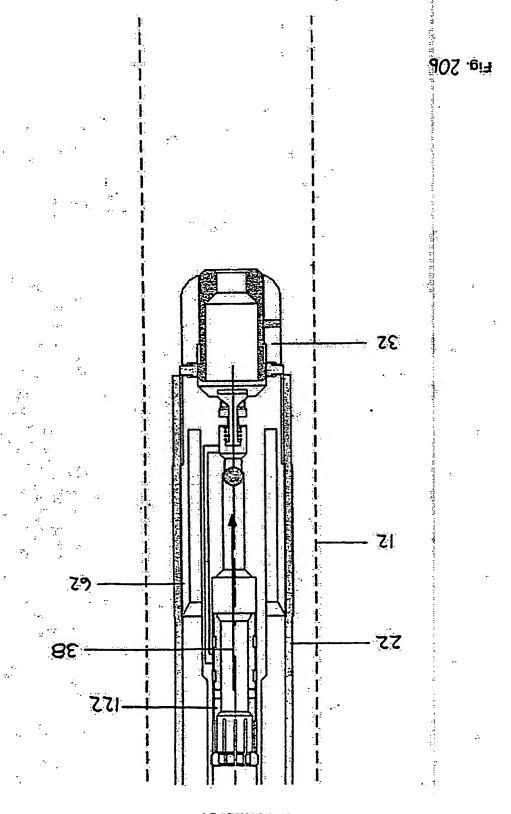
FIG. 186

FIG. 19

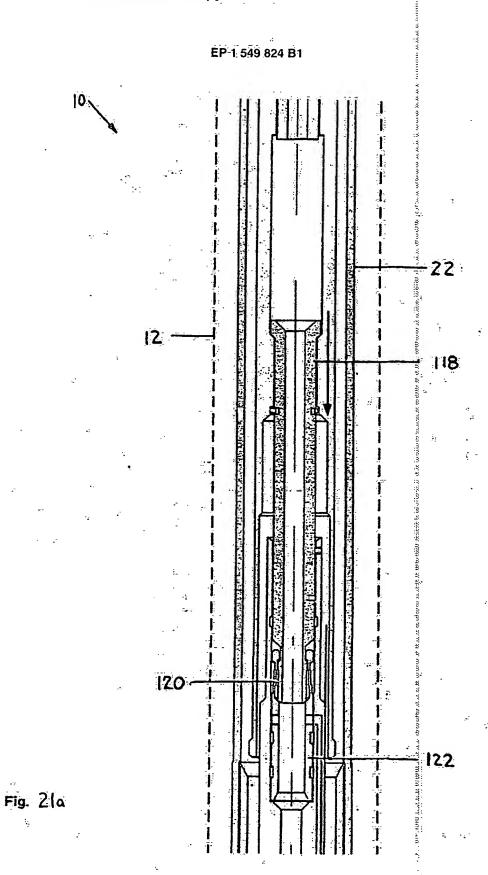


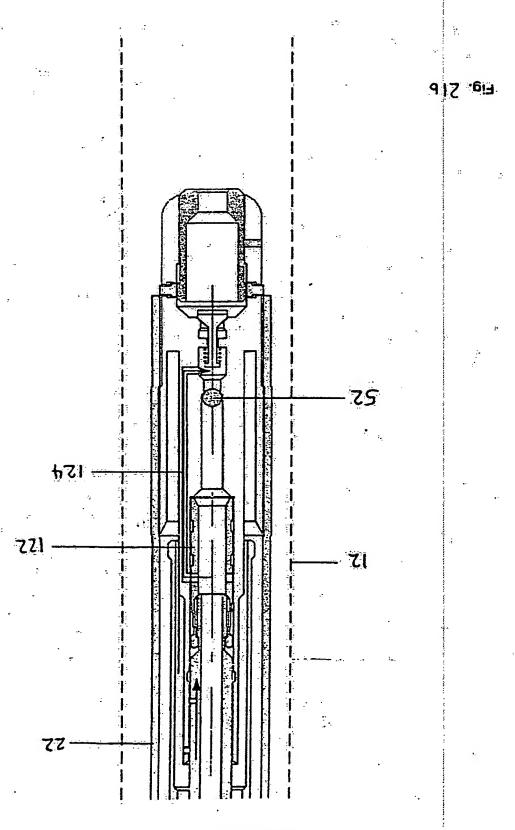
EP 1 549 824 B1



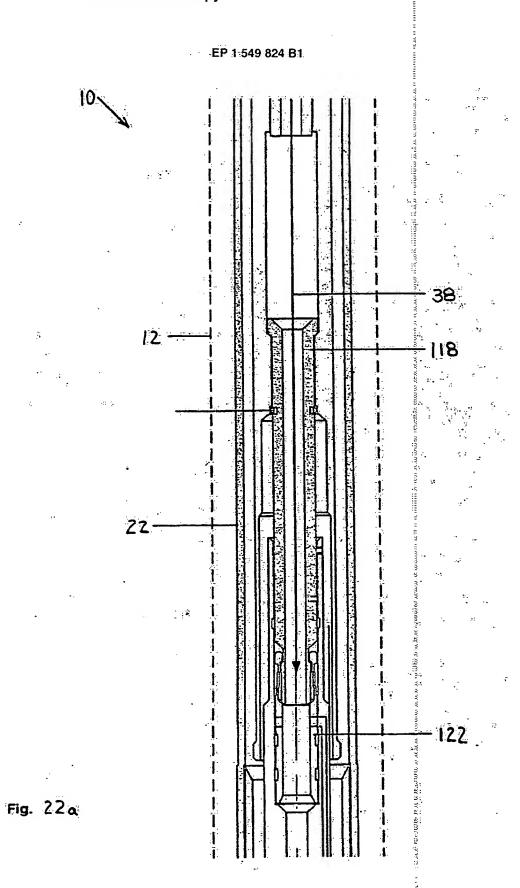


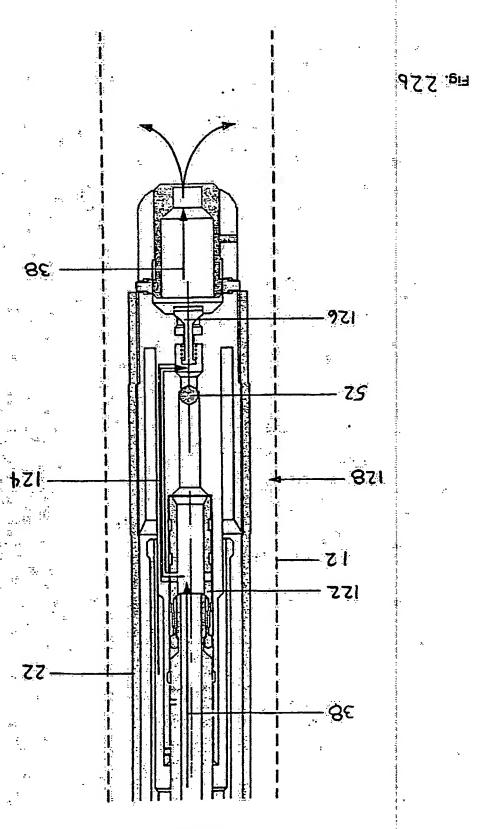
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